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Editor C. M. POULSEN

Managing Editor G. GEOFFREY SMITH

Chief Photographer JOHN YOXALL

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The Outlook

On Aircraft Controls

TWO articles which appear in this issue are of particular interest to aircraft designers: the one because it deals with the layout of the controls in the cockpit, and the other on account of the novelty of a new push-pull-cum-rotary system of control lines which should make for simplification, ease of maintenance, saving of space, and possibly for standardisation.

Many have been the discussions on the subject of standardisation of cockpit layouts, and a certain amount of uniformity has been achieved, but by no means as much as some could have wished. Our contributor this week, who is a test pilot of long and very varied experience, comes to the conclusion that standardisation is impossible, and is not worth the extra trouble and complication involved. "Sparrow" makes two interesting suggestions: that the pilot's cockpit should be divided into three zones, and that each control should always be allocated to a certain zone, although its actual position in that zone could be varied; and that control levers or handles of any given control should always be of the same shape, length and colour. Arising out of the latter suggestion follows the very logical one that indicator dials should match in colour the control handle to which they relate. "It does not matter a scrap," our contributor states in emphasising his plea, "how the lever works the flap, whether it be through bits of string, masses of bell cranks, or miles of pipes."

The second article to which we have referred deals with the avoidance of precisely these "bits of string and masses of bell cranks." The pilot is not greatly interested ("Sparrow" writes from the pilot's point of view, of course) in that aspect, but the designer definitely *is*. If the type of flying control proves satisfactory in extended service, there does appear to be a chance of standardisation. The aircraft manufacturer would probably have in stock the three tube sizes specified in any case, and all he would have to do, therefore, would be to buy the bearings, gear boxes, square-section rods, connectors and adjusters, etc., and assemble them, very much as a youngster assembles a set of standardised Meccano parts. A simple process indeed.

However, the matter may not prove quite so simple, and it will be chiefly the pilot (in spite of "Sparrow's" disclaimer) who will have to decide after a thorough test. The rotary movement of this type of control must be arranged to match-up with the linear movement in the matter of harmonisation of controls. If difficulty should arise the appeal of the system would suffer. Practical experience alone can provide the answer, but the Saunders system is in any case a welcome contribution to a problem which merits more careful study.

The R.A.F. in Libya

ALL has gone well on the Libyan air front in recent weeks. It is for the Army authorities to discuss why the battle round Sidi Rezegh took so long. The Prime Minister admitted that things had not gone as fast as had been expected. In other quarters disappointment has been expressed because, as we had air superiority, we did not finish the matter off at once. The public has been told many times that the British or their Allies lost battles because the enemy held the air superiority, and, naturally, people came to expect that

when we did have an admitted superiority in the air the matter was really all over bar the cheering.

The disappointment felt at the length of the pauses during the early phases of the battle is really due to the propagandists who have made the public believe that the air is everything in war. *Flight* has always preached that the aircraft with an army are but one arm, quite as essential as tanks, artillery, and all the other arms, but not by themselves magic makers of victory. An army can no more win without help from the air than it can win without help from tanks, but one cannot safely say much more than that.

There is every reason to believe that in this Libyan battle the air squadrons of the Empire have been used with excellent judgment. They have not attempted to achieve the impossible, and they have concentrated on the jobs for which they were most suited. By sticking to such sensible tactics they have given the ground forces the best service of which they were capable. Light tanks they could and did tackle on occasions, but their most useful work was to reconnoitre and to attack the enemy's supply, while at the same time preventing the *Luftwaffe* and the *Regia Aeronautica* from interfering much with our ground troops.

Luftwaffe Strength

IT may be noticed that the communiqués in which the Russians announce some of the details of their victorious advance have lately been very modest as regards the numbers of German aircraft destroyed. A statement on December 22nd, for example, claimed that the troops of General Boldin, operating on one of the sectors of the Moscow front, had captured or destroyed 12 German aircraft, 143 tanks, 760 lorries, 383 motor cycles, 101 guns and many smaller arms. The contrast between the huge numbers of other weapons and the mere dozen aircraft is certainly striking. It looks as if the *Luftwaffe* has been giving up the struggle in Russia, and had been withdrawing while the going was good.

Some time ago Mr. Churchill said that the only German weakness was in the air, and at the Lord Mayor's banquet last month he asserted that we now had an Air Force which was equal in size and numbers to the German air power. It is clear that the responsibilities of the *Luftwaffe* have outrun its strength; but, even so, that hardly accounts for the apparent paucity of German aircraft on the fighting fronts.

One comforting fact we know, namely, that the daylight sweeps by the R.A.F. over France have confined an unduly large proportion of the best German fighters to that area, and that without sufficient fighters the help which bombers can give to an army is almost negligible. Perhaps that fact has had a considerable effect in facilitating the present victorious Russian advance. If the German troops in Russia have really been almost denuded of air support, the Russian advance may continue almost indefinitely. That will present another pretty problem to Commander-in-Chief, Herr Adolf Hitler.

WILD HORSES: Built to Air Ministry specification, the North American Mustang single-seater fighters are now coming off the production lines in California. The Mustang is powered by a 12-cylinder liquid-cooled Allison engine of 1,150 h.p. Gross weight is 7,724 lb. Length, 32ft. 2in. Span, 37ft. Height, 11ft. 8in. No details of speed, armour or armament may be published. Other photographs appear on pages 5 and 15.

War in the Air

Beaufighters refuelling and rearming on an advanced landing ground in the Libyan Desert.

Hitler Drops the Pilot : The Agile Buffalo : Pressing on in Libya : The Malta A.A. Barrage

APART from fighting of special and perhaps personal interest to British readers, the great news of the moment is the assumption of the supreme command of the German Army by Adolf Hitler himself, and the dismissal of the former Commander-in-Chief, Field Marshal von Brauchitsch. This action by the Führer is a confession that the recent backward movement of the Germans in Russia is no mere straightening of the line "according to plan," but a defeat on a major scale. It would be hard to say at the moment which is of the greater strategic importance to the cause of the Allies, the failure of the Germans to win the Battle of the Atlantic or the German defeat in Russia.

Hitherto it must be admitted that von Brauchitsch has been a most successful, perhaps a brilliant, commander. All the land campaigns under his direction have been carried through like a book, as the saying is. In the invasion of Russia he had the great advantage of initial surprise, for Hitler did not declare war and the Germans started their invasion before the Russians were ready. An immense area of Poland and Russia has been occupied by the invaders, and, though the doggedness of the Russian resistance and the equipment and fighting power of the Red Air Fleet came as surprises to the Germans, the latter continued to advance and to hold the initiative. It may well be found that the true cause of the recent turn of the tide was Hitler's insistence that Moscow must be taken before Christmas, cost what it might in men and material. An important contributory cause seems to have been the changes in the Russian army group commands at just the right time, for Marshal Timoshenko has certainly been a brilliant success in the south—that very critical front, behind which lie supplies of oil.

Whatever the cause, there is no doubt that in October the Germans mustered for a great advance. One rumour said that the *Luftwaffe* had concentrated no less than 5,000 aircraft to help the German armies. Then the tide turned, and the Russians were able to seize the initiative all along the line, and it has been stated that their aircraft outnumbered those of the Germans on many sections. Any psychologist who has made a study of the ways of dictators would probably have prophesied that after such a debacle Hitler would dismiss his Commander-in-Chief—and so it has happened.

It would greatly enhance the Christmas cheer in the United Kingdom if we could all feel certain that Adolf Hitler intended personally to direct the movements of his armies. He is a brilliant villain in many ways, but there is no reason to suppose that he is capable of acting as a General. His

FOR JAP DIVE-BOMBERS: U.S. Barrage balloons flown at Army exercises.

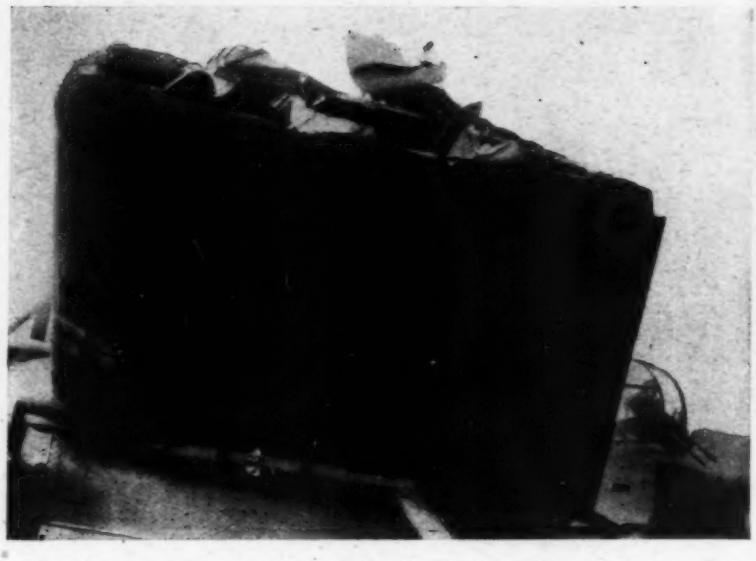
WAR IN THE AIR

outpourings in his proclamation ("I know war . . . I was wounded twice") are merely an appeal to the sentimentality of the German people. He will doubtless work through the General Staff. None the less, we may feel glad that von Brauchitsch will no longer command the German armies.

The Daylight Raid on Brest

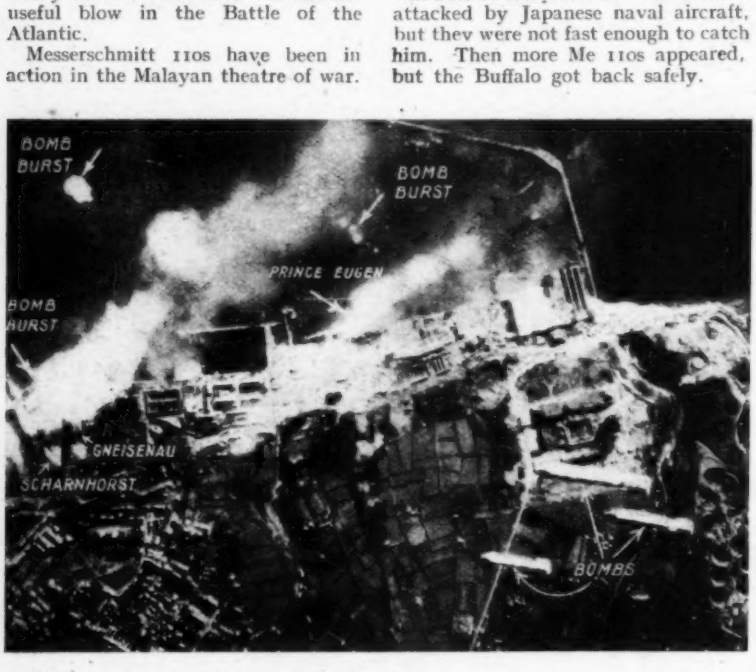
IN the northern area of war, before Christmas the R.A.F. resumed its activities against the warships in Brest harbour. First came a heavy night bombing of that naval base, and on the following day at 12.30 p.m. a new assault began in brilliant winter sunlight. This was briefly touched on in our last issue, but further details are now to hand. Stirlings went in first, then Halifaxes, and, finally, Manchesters. A strong fighter escort flew overhead and fought fierce battles with the German fighters. Other British fighters covered the withdrawal of the bombers. Very few of the Messerschmitts were able to attack our bombers, and of those that did four paid the penalty of their temerity. The heavy bombers went in to the attack in perfect formation, having decided that it was best to take their chance with the *flak* while preserving a united front against the Messerschmitts. It is believed that both the dry docks in which the *Gneisenau* and *Scharnhorst* were lying were hit by heavy bombs. This raid was another useful blow in the Battle of the Atlantic.

Messerschmitt 110s have been in action in the Malayan theatre of war.



WINGLESS FLYING : Last week we published a picture of a Beaufighter which came home minus most of one wing. This week we have a Beaufort which tried conclusions with the rigging of a vessel off the Dutch coast.

An R.A.F. pilot in a Brewster Buffalo had crossed the Thai border on reconnaissance when he was attacked by four of these German machines which came at him 14 times. His duty was to get back with his information, which meant avoiding a fight if possible. He found that his Buffalo was so much more manœuvrable than the two-engined German fighters that he was able to escape. He was afterwards attacked by Japanese naval aircraft, but they were not fast enough to catch him. Then more Me 110s appeared, but the Buffalo got back safely.



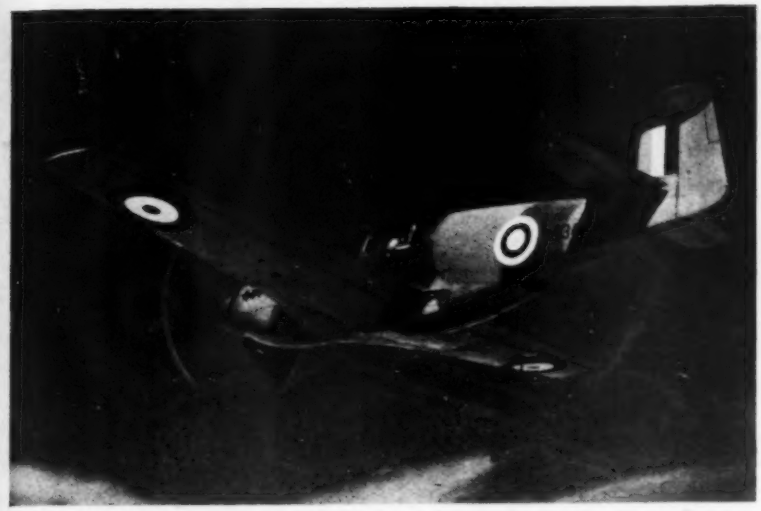
BREST RAID : A vertical photograph taken by a raider during a recent attack on the German ships in Brest harbour. Stirlings, Halifaxes and Manchesters all took part. Heavy armour-piercing bombs were dropped from sufficient height to ensure penetration.

Bad weather for some days handicapped our air operations in Libya, and also hampered a raid on Taranto harbour. But none the less the R.A.F. and Empire squadrons, assisted by some Free French bombers, have been destroying enemy supplies with gusto. One Blenheim squadron found a train near Zura, in Tripolitania, consisting of engine, three petrol tankers, and six coaches. The bombers came down low and played havoc with that train. Petrol lorries have also been shot up in numbers by both fighters and bombers. The Germans and Italians have been pushing hard to the west, evidently hoping to get at least part of their forces away into Tripolitania, and have left huge quantities of equipment behind. Our men have occupied over a dozen of their airfields, and have found at least 70 damaged German aircraft on them, besides quite 100 machines abandoned by the Italians. So rapid has been our advance that enemy airmen have not always known which landing grounds remained in their hands, and on one occasion two Messerschmitts landed on one which they thought was safe, and were at once taken prisoner by a party of British sappers.

Naval Night-fighters

MENTION was recently made in these columns of the good work done in Libya by a naval squadron which fights at night. It is pleasing to learn that its commanding officer, Lt. Cdr. J. W. S. Corbett, has been awarded the Distinguished Service Order—or, to be more accurate, has been made a Member of that Order.

Malta has not infrequently to endure day raids, when cloudy weather gives cover to the approaching bombers with their fighter escort. It



SOON FOR OPERATIONS : A three-quarter rear view of the new North American NA. 73 or Mustang. In the U.S. Army Air Corps it is the P-51. It is an all-metal job with a monocoque fuselage.

was interesting to read in a recent Air Ministry Bulletin that the island's anti-aircraft barrage has been described by some observers as "the most formidable in the world." Others believe that that distinction belongs to Moscow. It would be interesting to learn the views of German pilots who have experienced both. The Malta Hurricanes have also got a reputation for viciousness.

Japanese Aggression

THE loss of Hong Kong came as a shock to most Britons. Its airfield at Kai Tak was on the mainland and at once fell into Japanese hands, but that cannot be called the chief reason for the success of the Japanese. They certainly bombed the island at their will, but they also used artillery against the defenders, and landed troops at their pleasure. The gunfire cut off the water supplies of the gallant defenders, and this hastened their inevitable surrender.

The Japanese have also carried out a brutal air bombardment of Manila, which had been declared an open town. The damage has been extensive and deplorable.

In the Far East, Air Chief Marshal Sir Robert Brooke-Popham has been relieved of his post as Commander-in-Chief, and has been succeeded by Gen. Sir H. Pownall. The Japanese have bombed Kuala Lumpur, the chief town of the Federated Malay States, and have also landed parachute troops in the Dutch island of Sumatra. The R.A.F. has been striking back at airfields occupied by the Japanese.

Japanese successes in the Pacific can only be a flash in the pan, for the combined strength of the British Empire and the United States is far greater, once it has been organised and brought to bear on this enemy. Mr. Churchill and Mr. Roosevelt have been putting their heads together in Washington to decide how this can best be done.

In Lybia, Gen. Rommel's remaining forces have been steadily moving back in the direction of Tripolitania, leaving Benghazi and other places in British hands. His object is to save his tanks, while ours is to prevent their escape. The Empire air forces are manfully attacking his supplies, and this may bring him to a halt.

The Pacific is a sea and air problem —a matter for fleets and aircraft carriers.

BRITISH AIR LOSSES TO DEC. 27th.

	Over G.B. A'crft.	Over Continent B'brs.	Ftrs.	Pilots	Middle East A'crft.
Dec. 14	0	1	0	0	16
,, 15	0	1	2	2	5
,, 16	0	1	2	2	0
,, 17	0	1	0	0	3
					(2 pl'ts safe)
,, 18	0	5	1	1	
,, 19	0	0	0	0	
,, 20	0	0	0	0	195
,, 21	0	2	0	0	
,, 22	0	1	1	1	
,, 23	0	2	0	0	
,, 24	0	0	0	0	1
,, 25	0	0	0	0	2
,, 26	0	0	0	0	3
,, 27	0	7	0	0	1
					(pilot safe)
	0	21	6	6	226

Totals : North, 3,127 ; Middle East, 858.

ENEMY AIR LOSSES TO DEC. 27th.

	Over G.B.	Over Continent.	Middle East
Dec. 14	0	0	5
,, 15	0	0	0
,, 16	0	0	3
,, 17	1	0	2
,, 18	0	8	
,, 19	2	0	
,, 20	0	0	476
,, 21	1	0	
,, 22	0	0	
,, 23	0	0	
,, 24	0	0	6
,, 25	0	0	0
,, 26	0	0	0
,, 27	0	0	0
	4	8	492

Totals : North, 5,592 ; Middle East, 2,918

DELAYED ACTION IN ACTION : The sinking of an enemy supply ship in the Ionian Sea. D.A. bombs were used. From the top downwards :— The attack, showing the low height from which it was made. In the second picture the bomb is in the ship but has not exploded. Next the explosion and finally the ship on fire and sinking.

Class 1. The Miles Master, which has the Miles Control Unit. A step in the direction of uniformity.

OFFICES TO LET—OR HINDER

Standardisation Impracticable, but Uniformity of Cockpit Layouts Possible by "Zoneing"

By SPARROW

ONE of the most popular subjects for discussion among pilots, old and new, is cockpit layout. I have taken part in many of these arguments and there are always as many opinions as there are pilots present. Eventually someone suggests standardising the layout of cockpits, and it is very hard to convince them that, at worst, it is impossible and, at best, it is not worth it.

I have been lucky enough to have flown a good many types of aircraft and have kept photographic records of the cockpit layouts of quite a few of them. The following remarks and suggestions, based on this experience, will, I hope, leaven this old argument.

First, is standardisation necessary? And secondly, what degree of standardisation is possible and desirable?

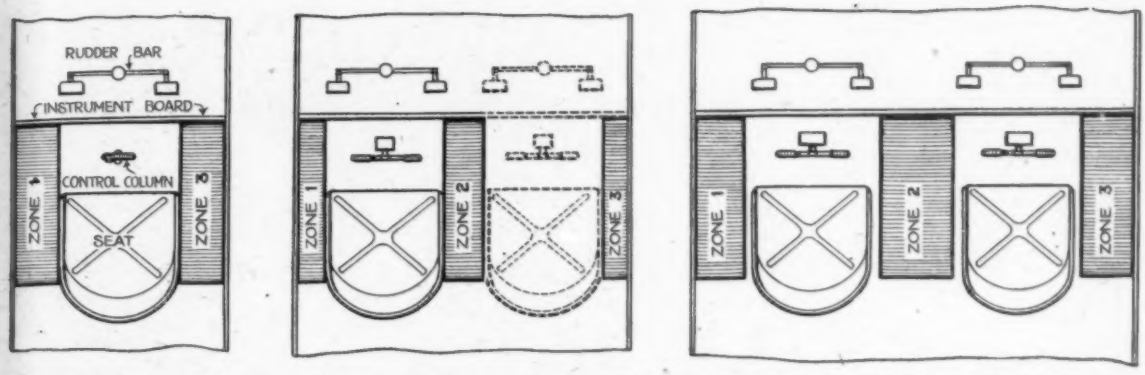
Only a limited degree of standardised layout is possible (of standardised details more anon), but in my opinion a much greater degree of uniformity is possible. In the R.A.F. the majority of pilots are flying one type and one only for quite long periods. The advantage conferred by a standard layout are largely lost except on those R.A.F. pilots whose job entails flying many types during a day, such as those at various Experimental, Communication and Maintenance Units, and, of course, the Ferry Pilots. Although these pilots have very few accidents due to confusing the controls on one type with those on another, they are the first to press for a more uniform cockpit arrangement.

Some years ago I was shown two cockpit mock-ups at Martlesham. These models were made in an attempt to standardise layout; one was for single-engined aircraft and one for multi-engined machines. As far as I know they were never completed, because at an early stage the impracticability of the scheme became apparent.

Who would care to design identical cockpits for a low-wing single-seater fighter and for a Parasol Army Co-op. machine? Or for a small twin-engined single-seater and a four-engined bomber? At the time when I saw these mock-ups, the industry was pretty hard up for orders, and had the originators of this experiment pressed their case, they would have stood a fair chance of getting the scheme adopted in spite of design and constructional complication. The fact that the policy was dropped and machines to each specification were treated individually, justifies the assumption that absolute standardisation is impossible.

Standardisation is a practical impossibility because it complicates control runs during installation and servicing; the extra complication means wasted weight, man-hours and cost as well as material. Complication of control runs is the final and most important factor in the way of a standard cockpit arrangement. The auxiliary control runs have a far greater effect on the position of the various auxiliary control levers and handles and, therefore, on the layout, than do the flying control runs.

There are two things to consider when fitting a component into a uniform layout. First, position, and



Diagrammatic cockpit lay-outs of the zone positions. On the left is shown the arrangement for Classes 1, 2 and 3. Large twin-motored aircraft (Class 4), with the dual control in dotted outline, is shown in the centre. On the right is the typical roomy "office" of four-engined aircraft and flying boats of Class 5.

secondly, appearance and action. As the position part of the layout cannot be rigidly standard, the position of the component is best determined by some such scheme as this. Divide all aircraft into, say, the following five arbitrary groups:—

Class 1. Single-engined Fighters and Trainers.

Class 2. Single-engined F.A.A. and Army Co-op. machines.

Class 3. Twin-engined Fighters and Reconnaissance types.

Class 4. Medium and Heavy Twins.

Class 5. Four-engined Landplanes and all Flying Boats (two- and four-motor).

The following reasons seem to justify the above tentative classification:—

Class 1 is almost an essential as it covers practically the only single-engined types used by the R.A.F. apart from Army Co-op. and Communication types. Communication types do not concern us as they are usually converted civil designs or obsolescent Service types.

Class 2. F.A.A. and Army Co-op. types are grouped together on account of their both being fitted with particularly comprehensive equipment.

Class 3. Twin-engined fighters and photographic reconnaissance machines are fast, handy and fairly light. They seem more like single-engined machines than twins to fly, and so there is no reason why the cockpit layout should not be single-engined in motif rather than following the cockpit design of a heavier twin (e.g., throttles, etc., on left).

Class 4. This will always be a large class, and their cockpits should have a characteristic twin-engine layout. Size will usually keep the smaller machines out of Class 3 and the larger out of Class 5.

Class 5. A fair degree of comfort can be built into the office of a four-engined machine owing to the extra space. This also applies to Flying Boats. It would be a pity to waste the extra space by utilising a cabin layout which is suited to a smaller machine.

The most practical way to determine the approximate position of a component in a so-called uniform layout is to divide the cockpit laterally into three zones (Port, Centre, Starboard) and allot each control to a certain zone depending on the classification of the aircraft.

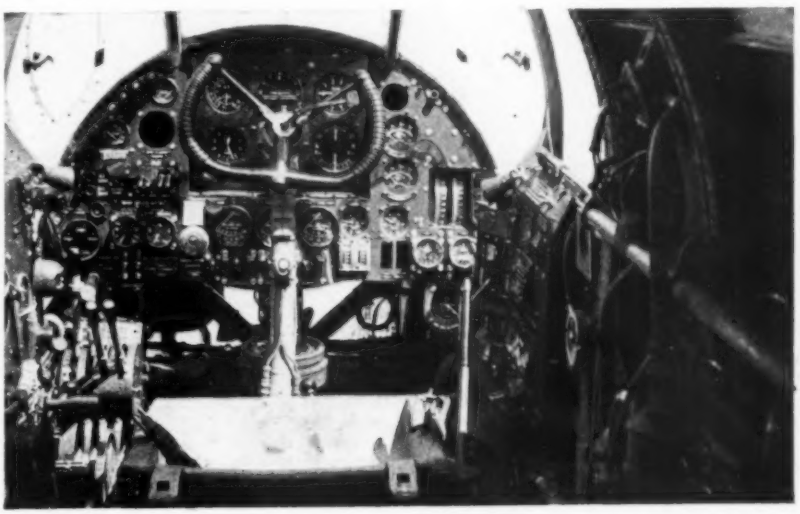
The following uncompleted table will explain the scheme.

Position in Cockpit.

Zone 1—Port.
Zone 2—Central.
Zone 3—Starboard.

AIRCRAFT CLASSIFICATION

Component	Class 1	Class 2	Class 3	Class 4	Class 5
	Zone	Zone	Zone	Zone	Zone
Trimmers	1	1	1	2	2
Flap lever	1	1	1	2	2
Undercarriage lever	1	1	1	2	2
Coolant control ..	1 or 3	1 or 3	1 or 3	1 or 2	1 or 2
Landing light lever (near throttle) ..	1	1	1	2	2



Although it is a twin-engined bomber the Handley Page Hampden comes into Class 3 because there is only one set of controls.

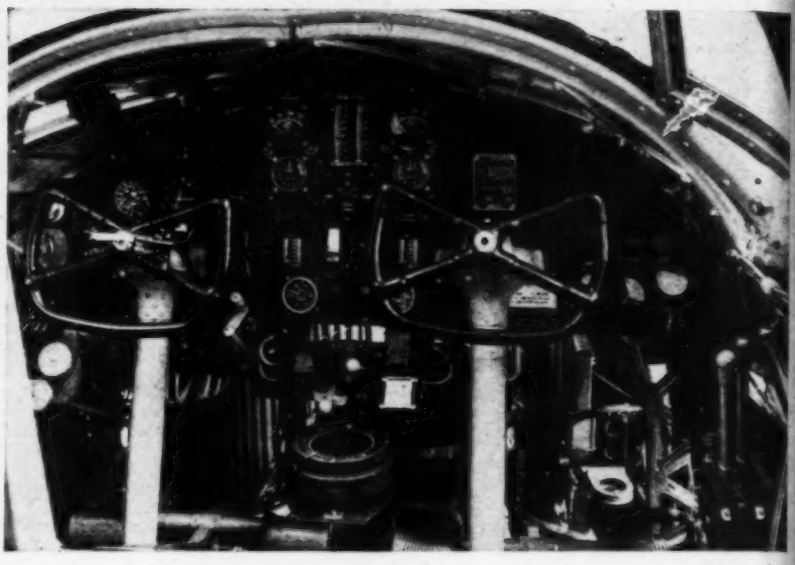
OFFICES TO LET—OR HINDER (CONTINUED)

The various zones allotted to each component for each class are only for illustrative purposes.

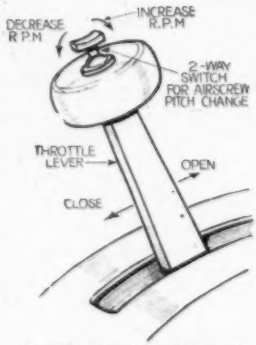
The list under "component" will be a very long one on modern aircraft, and some of the items may be allotted to alternative zones on certain classes of aircraft. This scheme strikes a happy balance between uniformity for the pilot and convenience for the designer, who is still free to move the component vertically and fore and aft within the appropriate zone, the exact position being determined on the mock-up. An item in Zone 2, for instance, will usually fall in a space between the engine control pedestal and the rear of the pilot's seat. Providing the control is accessible, its location should be sufficiently uniform to satisfy the pilot.

Lever Geometry

The second factor effecting uniformity is the detailed appearance and action of the control in the cockpit. Take, for example, the flap lever; now if this lever were absolutely identical as regards shape, length, colour and material, from the *ab initio* trainer to a four-engined bomber, and if all other levers were respectively identical, we should be approaching a very practical state of uniformity.



The Vickers Wellington with dual control is an excellent example of Class 4. A second set of throttle controls are fitted in Zone 3.



An example of an electrical control mounted on a mechanical control for convenience of operation.

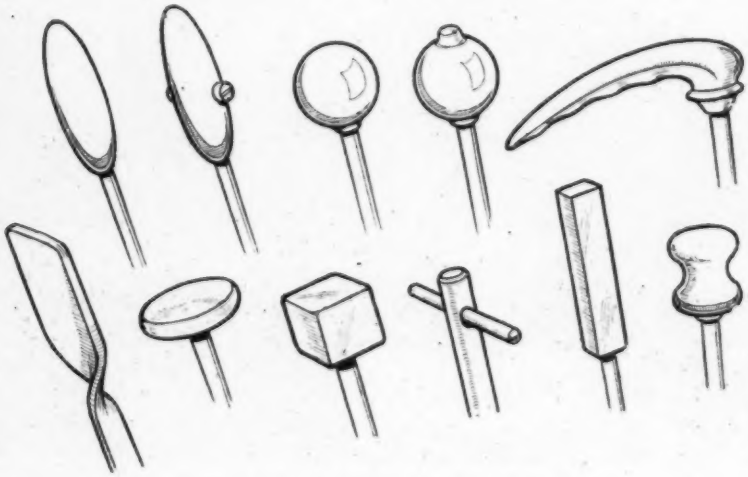
This can easily be done because it only affects the handle of any component—it doesn't matter a scrap how the lever works the flap, whether it be through bits of string, masses of bell cranks or miles of pipes. Having got distinctive and standard levers it is only necessary to insist that they are mounted so that they always work in the same sense (i.e., lever up, flaps up; lever down, flaps down. Some flap levers still have a fore and aft movement instead of the logical vertical one).

Knob Shape and Colour

To carry this idea to its logical conclusion, the knob of each control lever should be given a distinctive colour and, for night-flying, a distinctive shape. I should like to see this scheme applied to the controls for each of the following items: Undercarriage, flaps, coolant shutter, landing light, two-speed blower, etc. Whenever an instrument or an indicator goes with a control, it would be possible to make the lever and the rim of the instrument the same colour (e.g., the radiator shutter lever might be blue to match the radiator thermometer). The throttles, mixture controls and airscrew controls are already mounted in a sufficiently uniform way, and I would only suggest that the practice of colouring port and starboard controls be discontinued so as to accentuate the importance of the colours allotted to the other control levers. Red and green knobs on throttle levers, etc., are decorative but unnecessary.

The only reason for trying to obtain a standardised cockpit arrangement is to eliminate accidents due to the pilot failing to

(*Continued on page 9.*)



A selection of different shaped knobs which might be standardised for various controls irrespective of their position in the cockpit.

GOOD HUNTING IN 1942

A STUDY OF SHELL-FIRING HURRICANES IN ACTION ABOVE THE CLOUDS

A reproduction of a superb coloured canvas executed for "Flight" by F. Gordon-Crosby.

In the evening of May 10, Rudolph Hess, Deputy Führer of the Third Reich, flew over in a Me 110 and baled out over Scotland.

1941 IN RETROSPECT

"If you can meet with triumph and disaster
And treat those two impostors just the same . . . ."

—KIPLING

MR. WINSTON CHURCHILL, ever since he became Prime Minister, has warned the country that there would be ups and downs in the fortunes of war, and when we look back on the tale of A.D. 1941 we find plenty of examples of both. Fairly it may be claimed that the British Empire has fulfilled the condition laid down by Rudyard Kipling; it has not been unduly jubilant over its successes or depressed by its setbacks. Both Triumph and Disaster have proved themselves to be imposters, for neither has led to the decision which either we or our enemies may have hoped or expected. The Empire collectively may claim, without undue complacency, that it has deserved Kipling's conclusion: "You'll be a man, my son."

The year started with bad weather, and the intensity of the German night raiding of Great Britain was slackening. Partly on account of the weather, but even more of set purpose, the air attacks were beginning to assume a different character. Evidently the German High Command was beginning to abandon the hope that intensive bombing of the Capital would break the British *moral* and induce a desire for peace at any price—even for surrender to Hitler and acceptance of the worst terms which he could impose, provided only that the citizens of London might be freed from the fear of sudden death by night.

That German hope had proved vain, and the High Command turned its energies to the more hopeful (as they thought) object of reducing Britain by cutting its "life line" from North America. The night raiding was directed more and more against the ports of Britain, chiefly those on the western side of the island, as a help to themselves in the new phase of the Battle of the Atlantic. Consequently, the chief weight of the *Luftwaffe's* night bombers was turned on to Southampton, Portsmouth, Plymouth, Bristol, Swansea, Cardiff, Liverpool, Manchester, all Merseyside, Glasgow and Clydeside.

The destruction done in these cities and areas was grievous, but the citizens bore it all with the same fortitude which had been shown by the people of London. Moreover, the ports were never put out of action. We had ourselves learnt from our experiences in bombing Hamburg, Bremen, Kiel, Emden and other places in Germany, what an enormous weight of bombs is required to make a port useless. London and the Thames Estuary still had to bear raids every now and then, and Hull and the ports in East Anglia were also fairly regular targets for the Germans. Birmingham also suffered.

Turning to other sections of the wide battle front, the opening of the year saw General Wavell's men pushing on in their marvellously rapid conquest of Cyrenaica, which reached as far as Benghazi. It turned out that we could not retain our hold on that province, but our dash put out of action the large Italian army with which Marshal

The Battle of the Atlantic has gone on for the whole 365 days. Sinkings during the latter part of the year were only a fifth of those at the commencement.

A feature of the year's operations by Fighter Command has been the numerous sweeps over occupied territory by cannon-armed Spitfire Vs (above) and Hurricane IIs (right).

Graziani had been threatening Egypt. That army was all killed or captured, and no subsequent success by the enemy could replace it. In that campaign the Royal Air Force, stoutly helped by the air forces of South Africa and Rhodesia, obtained an undisputed mastery over the *Regia Aeronautica*, and played a tremendous part in General Wavell's success. The Navy had also co-operated wholeheartedly and with great effect.

In Greece and East Africa

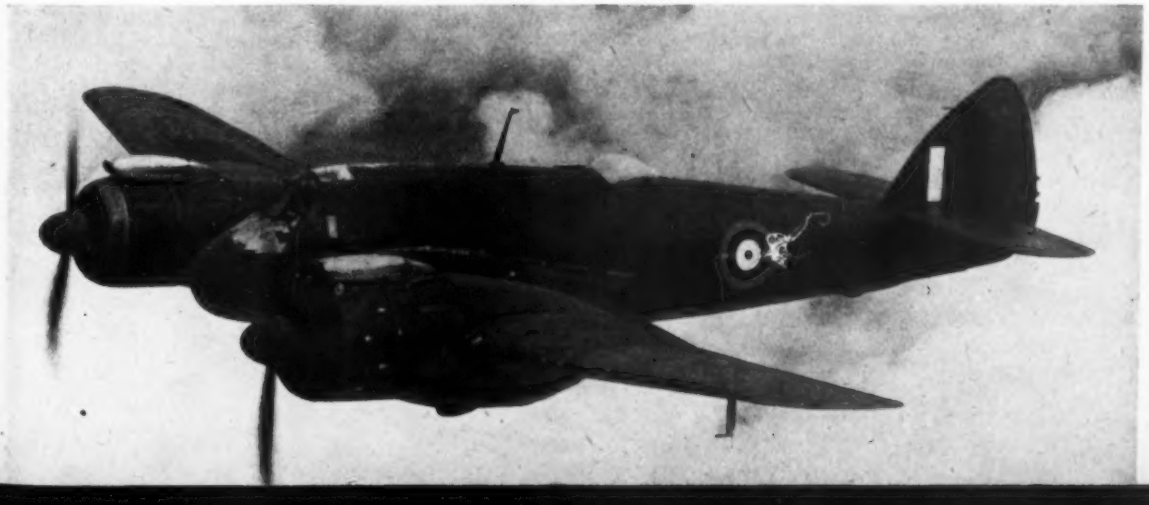
The superiority of the R.A.F. was also clearly manifested in Albania, where the Greeks were steadily pressing back the Italians, though the bad weather of January had slowed up their advance. The number of British fighters, Hurricanes and Gladiators, in Greece was small, but the pilots would attack any number of Italian fighters, and always had the best of the encounters. Blenheims helped the Greek Army in its advance, and British bombers, mostly based on Crete, constantly raided the Italian ports of Valona and Durazzo in Albania, and Brindisi in Italy. Things seemed to be going well there.

They were going even better in East Africa, where the South African Army and its air force, based on Kenya, and helped by regiments of native African troops from both East and West Africa, were beginning the invasion and conquest of Italian Somaliland, and ended by recovering British Somaliland (which the Italians had occupied the year before) as well. Indian and other Empire troops, including a contingent of Free French, were invading the Italian colony of Eritrea farther to the north, while the re-conquest of Abyssinia was beginning. These three campaigns were the greatest success of the British and Allied arms in the year. There was very hard fighting, and the storming of Keren in Eritrea by the Indians will remain one of the epic victories of this war.

In the wooded and mountainous country in which these campaigns were waged, it was particularly difficult to get artillery up to the places where the infantry needed its support, and so bombardment from the air was regularly used to replace it or to supplement it. It is a sound rule never to ask bombers to do what can be done by gunfire, but when one is short of artillery at a certain spot it is legitimate, and, in fact, only common sense, to use bombers. Of course, those tactics can only be used if the bombers do not run the risk of annihilation by enemy fighters, but that condition obtained throughout the East African campaigns.

Not only did the Hurricanes and Gladiators beat the Italian fighters whenever they met them in the air, but large numbers of enemy machines were put out of action by our raiding of their airfields. Probably, after this war, a volume may be written on the subject of bombing airfields, setting forth the conditions which make it sometimes so futile (as at Stavanger and in the Battle of

In the early night fights over England and in the present Libyan battles, the hard-hitting Beaufighter has proved its worth. It is armed with four 20mm. cannon and six ·303 machine guns.



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Britain) and sometimes so very effective, as in East Africa and Crete. Somaliland was conquered by the middle of March; Eritrea was in our hands by the middle of April. Addis Ababa was occupied by our troops about the same time, and the remaining Italian forces in Abyssinia were reduced one after another.

The last place to hold out was Gondar, and it was left alone during the rainy season, and finally forced to surrender by the end of November. In all these operations, aircraft, mainly the South African Air Force, played a most prominent part, both by reconnaissance (a very important matter in such difficult jungle country) and as a striking force.

The Germans Come South

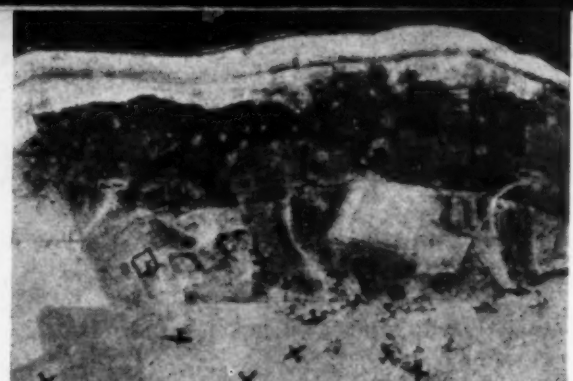
The failure of the *Regia Aeronautica* all over the Middle East and the Mediterranean induced Hitler to send a force of German aircraft to the help of Italy, and a large contingent, with a high proportion of Ju 87 dive-bombers, was stationed in Sicily. Germany was also showing signs of preparing to invade Greece, and it became important to send stores and troops to that country. On January 10th an important convoy, mainly intended for Greece, was escorted through the Sicilian Straits by the Mediterranean Fleet. It was heavily attacked by Stukas on the way, and the carrier, H.M.S. *Illustrious*, was damaged internally by bombs. The cruiser *Southampton* was also hit and had to be sunk by our own ships.

The *Illustrious* was taken into Malta harbour, where first aid was administered, and then she steamed off to Alexandria, and was finally repaired in an American dockyard. While she was lying at Malta the Stukas made great efforts to destroy her, but they failed, with heavy losses to themselves. At the same time, our bombers raided the Sicilian airfields. As a result of the whole incident, the Germans lost 90 Stukas—50 shot down in air combat and 40 destroyed on the ground. The place of H.M.S. *Illustrious* with the Mediterranean Fleet was taken by H.M.S. *Formidable*.

Meanwhile, transports were taking British troops to Greece. Warships had to guard the convoys, and aircraft had to add their protection. It was not possible to watch the crossing from Italy and Sicily to Africa at the same time, and the Germans succeeded in getting a large force, with tanks, across there. There was a rumour that a German expedition was to sail from Genoa for some port in Africa, so the western part of the Mediterranean Fleet, under Admiral Somerville, accompanied by the *Ark Royal*, bombarded Genoa in February, while the aircraft from the carrier bombed objectives round Leghorn and Pisa. Shortly afterwards a party of British parachute troops landed in Southern Italy, but the objects and details of the raid have not been disclosed.

Then, towards the end of March, the Germans advanced on Cyrenaica, defeated a too venturesome British column, and took two Generals prisoner. General Wavell, with his force depleted by the needs of Greece, withdrew, only holding on to Tobruk, and the Axis forces once more reached the frontier of Egypt.

With the Germans massing in the Balkans and the British retreating in Libya, the Italian Fleet plucked up heart to sally forth. A Sunderland spotted their ships and sent in an urgent report. The result was the battle of Matapan, in which T.S.R. machines from H.M.S. *Formidable* planted torpedoes into the Italian battleship *Vittorio Veneto*, Blenheims bombed other Italian ships, and Admiral Cunningham's battleships sank two or more Italian cruisers. This was some consolation for the British setbacks in Libya.



In June the Germans captured the island of Crete by the use of airborne troops. Gliders were used in large numbers. This photograph shows Junkers Ju 52s — mostly wrecked — on Maleme airfield.

The Failure in Greece

But in April the Germans fell upon Yugoslavia and Greece in strength. Their aircraft outnumbered those which the Empire and Greece could muster there, and German air superiority, accompanied by overwhelming numbers of Panzer divisions, speedily overcame all opposition. After hard and gallant fighting, the British troops and squadrons, as well as some of the Greek troops, were evacuated, some to Egypt, some to Crete. During the month of April, 250-odd Axis aircraft were destroyed by the Middle East Command, but too many were left over.

There promptly followed Rashid Ali's revolt in Iraq, which had been pretty well denuded of British troops and aircraft. For a short while the R.A.F. station at Habbaniyah seemed to be in danger, but prompt and daring air action averted the danger. Indian troops were flown up in bomber-transport machines, and R.A.F. squadrons were found somehow and sent to the scene of action. The revolt speedily collapsed.

The Germans, at the time, were busy invading Crete by air. We had left no aircraft on the island, and the Navy undertook to see that no enemy troops should reach it by sea. It was decided to try whether our ground troops could hold the place without air support. The experiment may well have been worth making, but it failed. At great loss to themselves, the Germans poured in men by troop-carriers and gliders, some of them landing by parachute, while Stukas battered our gun posts and infantry. As a result, an air attack, unsupported by Panzers, over-

H.M.S. *Victorious*, the aircraft carrier which played a prominent part in the sinking of the *Bismarck*. H.M.S. *Formidable* has also been completed and taken part in operations.

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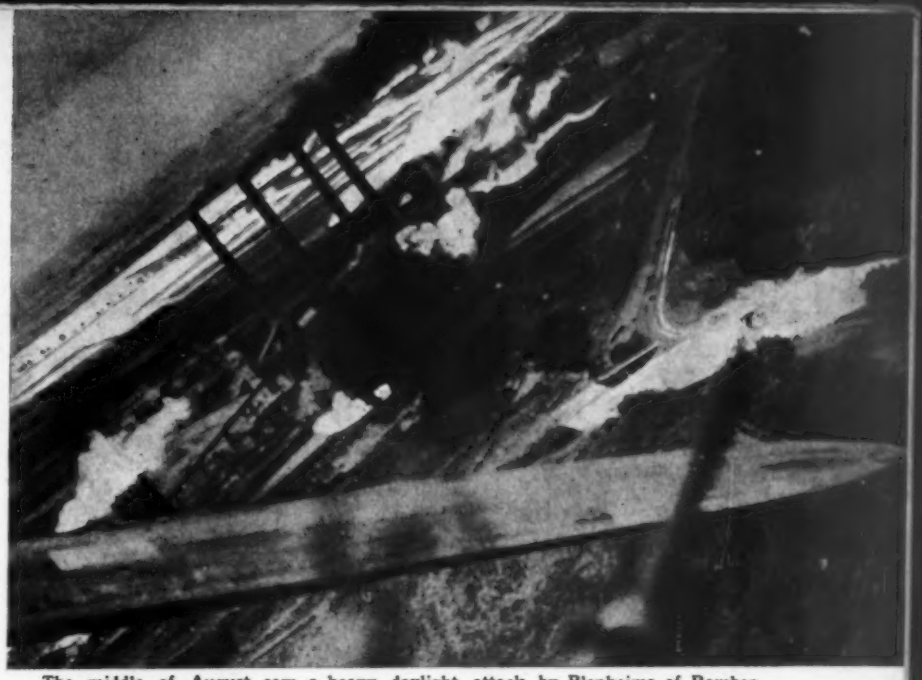
came a ground defence unsupported by aircraft. A considerable part of our troops was evacuated with the help of the Navy, but our losses were grievous, especially in cruisers and other ships.

However, the defence of Crete saved Iraq and Syria. German aircraft began to land in Syria with the connivance of the Vichy authorities. Consequently our authorities decided to occupy the country, and the Free French (who had hitherto declined to fight against their countrymen) agreed to co-operate. In this campaign we had air superiority, and, after sharp fighting, the Vichy French surrendered in July. The Free French took over the country. We must not leave the sphere of the Mediterranean without a tribute to gallant Malta, so resolute in defence, so incisive in hitting back.

The war entered upon a new phase when, on June 22nd, Hitler invaded Russia without a declaration of war. The Russian resistance surprised the whole world, but their troops were slowly driven back. Strategically, the most dangerous development was the German advance in the Ukraine, which threatened the oilfields of Russia, and also of Persia and Iraq. Accordingly, towards the end of August, Russian and British-Indian forces both entered Persia. The autocratic Shah abdicated, and his son began a new policy of friendship with the Allies. These successes in western Asia were a considerable offset to the Allied losses in Greece and Crete. We may pass over some intervening months to say that, as the year drew to a close, Marshal Timoshenko reorganised the Russian forces in the south and commenced to drive the Germans back. On nearly all parts of the long front the Russians developed air superiority, and the Germans also were driven back from in front of Moscow.



The middle of August saw a heavy daylight attack by Blenheims of Bomber Command on the power station of Cologne. The Blenheims flew at 50 ft. or less all the way from the coast and back.

New Advance in Libya

This reversal of fortune coincided with, and was doubtless related to, a new advance in November by British forces in Libya. Here we held an undoubted air superiority, both in numbers of aircraft and in the ability of our pilots and crews. On the ground the fighting was mainly between tanks, and it was found that attacking heavy tanks was not the best use to which aircraft could be put. While Empire fighters kept the mastery of the air, reconnaissance machines provided information of what the enemy was doing, and our bombers concentrated on destroying his supply columns. The Germans made desperate efforts to strengthen their air squadrons, withdrawing units from other areas, but in vain. The *Luftwaffe*, after its serious losses in Russia, was at last stretched beyond its capacity.

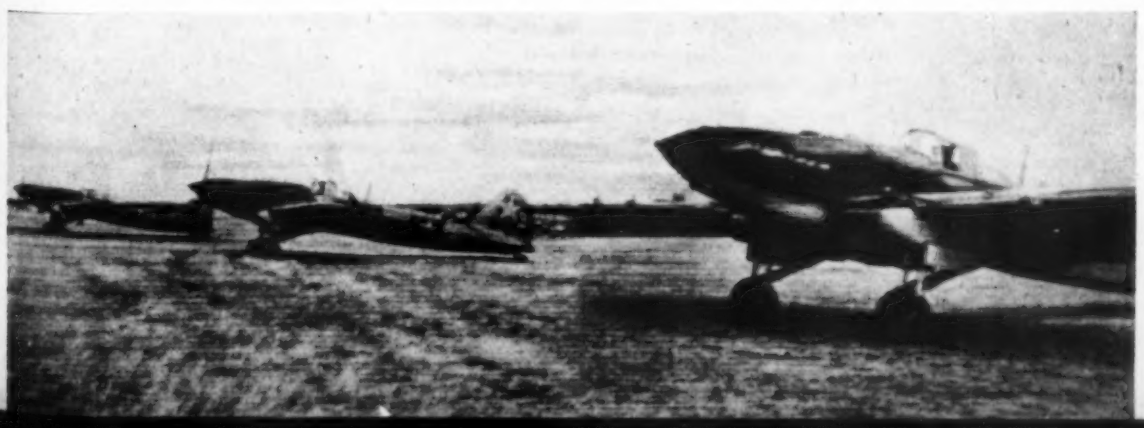
Before this Libyan battle began, the Navy and the Air Force had been making strenuous attacks on the convoys which the enemy was sending from Europe to Africa, and had been sinking a high proportion of the ships. Our bombers also regularly raided the ports of embarkation, especially Naples and Brindisi, and the ports of arrival, Tripoli, Benghazi, and others.

H.M.S. "Ark Royal"

Throughout the summer a number of sweeps was made by both sections of the Mediterranean Fleet, and the *Ark Royal*, which was based on Gibraltar, had many adventures and many escapes. The coming of the Fulmar fighters greatly helped the carriers in the Mediterranean, for their speed and gun-power enabled them to catch and speedily destroy enemy scouting machines which might otherwise have escaped, and also to shoot down dive-bombers in considerable numbers. But in November the stout old *Ark Royal* fell a victim to a torpedo, and sank, despite gallant efforts to get her into port. Only one rating was lost.

But before she was lost, the *Ark Royal* had taken a prominent part in the Battle of the Atlantic. During the summer the rate of sinkings caused no little anxiety, which the Prime Minister did not attempt to conceal. The Navy had to contend with U-boats based on Lorient and Focke-Wulf Condors from Merignac, near Bordeaux. In addition German battleships, battle cruisers, and other cruisers went out raiding in the Atlantic. In February, a 10,000-ton cruiser of the *Hipper* class was known to have entered Brest harbour, and Bomber Command made violent attacks on the place, but the warship seems to have escaped. Then in March the powerful warships *Scharnhorst* and *Gneisenau* returned to Brest from the Atlantic and the latter went into dry dock. At once Bomber Command launched a long series of heavy raids on that port, which was very strongly defended. Armour-piercing bombs had to be dropped from a height at which they would be able to

Our Russian allies pulled several good types of aircraft out of the bag. Among them was the shapely Stormovik dive-bomber shown below.



1941 IN RETROSPECT

develop their terminal velocity, and from that height accurate aiming was not easy, especially in the glare of many searchlights. However, both vessels were obviously damaged, as neither of them put to sea again. In July the *Scharnhorst* tried to slip away, and reached La Pallice, near La Rochelle. The watchful eyes of the R.A.F. soon found her, and for two consecutive days and the intervening night, R.A.F. bombers hammered both La Pallice and Brest. Stirling and Halifax four-engined bombers made the day raids on La Pallice; Fortresses and Hampdens took on Brest. Our losses were not light, but the *Scharnhorst* gave up her attempt, and returned to Brest, where she went into dry dock.

The "Bismarck" Sunk

May was an adventurous month in the Battle of the Atlantic, and it also saw the curious incident of Rudolf Hess flying from Germany and landing by parachute near Glasgow. The newest German battleship, the *Bismarck*, attended by the cruiser *Prinz Eugen*, went out to raid in the Atlantic. After a fight in which she sank H.M.S. *Hood*, the *Bismarck* tried to get back to Brest (which the *Prinz Eugen* succeeded in doing) and nearly evaded the pursuit of the Home Fleet. A Catalina of the Coastal Command found her, and then carriers sent their torpedo aircraft against her. Both H.M.S. *Victorious* (in action for the first time) and the *Ark Royal*, which had hastened up from Gibraltar, shared in the credit of slowing the battleship down. Finally she was sunk by the Home Fleet.

The Navy, with its Air Arm, and Coastal Command, had to fight the Battle of the Atlantic. Coastal aircraft flew over the convoys as far out as their range allowed.

Handley Page Halifaxes with their four Rolls-Royce Merlin engines have carried heavy loads of bombs to the Ruhr, Berlin, and beyond.

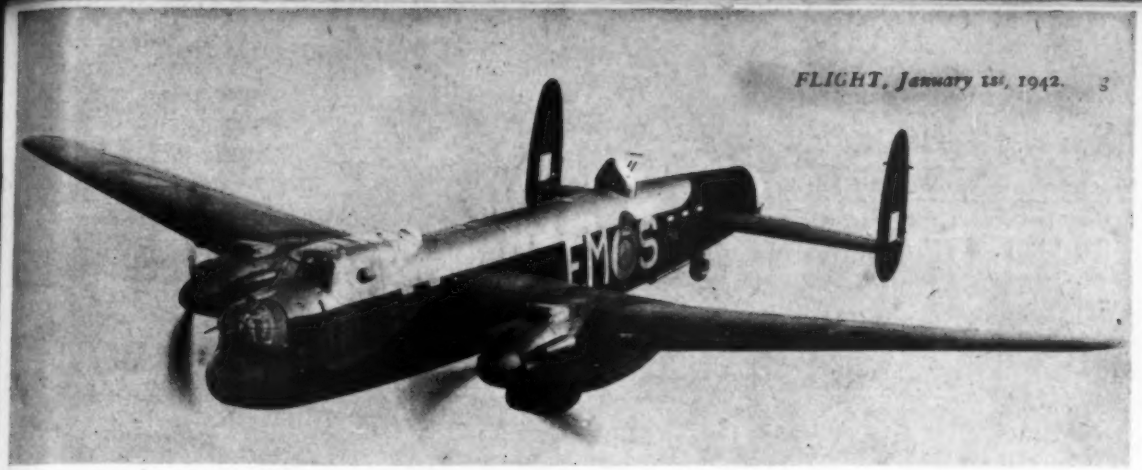
During the summer a Hudson shot down a Condor, and shortly afterwards another Hudson drove a Condor away. In September yet another Hudson bombed a U-boat and damaged it so that it had to surface and surrender. A naval boarding party brought it in to a British port. Another form of protection was to fit catapults on to merchantmen and to fly off Hurricanes. A Condor would have small chance of escape from such a fighter, and even though the Hurricane usually had to be abandoned, the pilot could hope to be picked up.

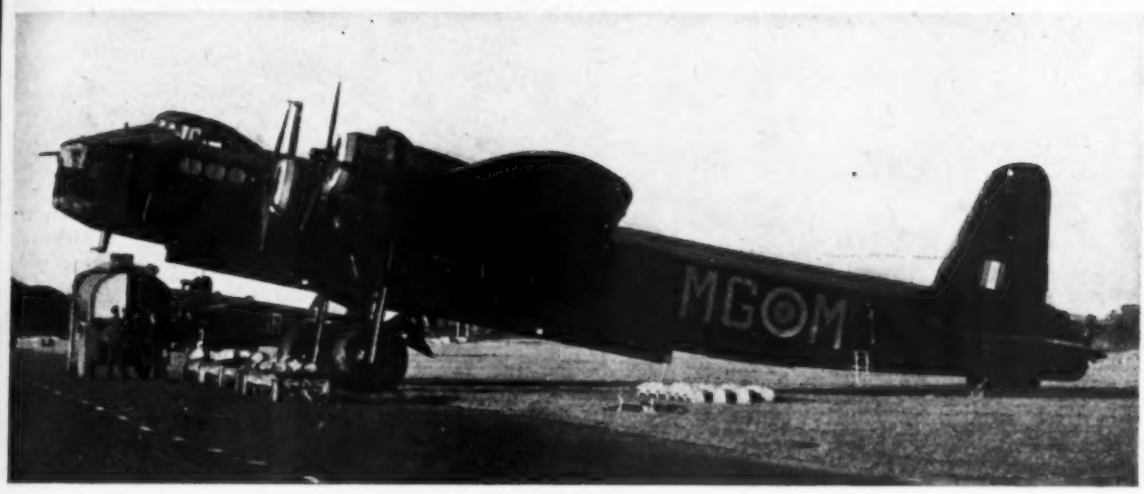
All through the year the R.A.F., working through Bomber, Fighter, and Coastal Commands, has been intensifying its attacks on Germany and the countries which she has occupied, as well as attacking with bomb, torpedo (launched from a Beaufort), shell, and machine gun, the coastwise shipping which the Germans have extensively used to ease the strain on their land communications.

The new fighters, fitted with shell-guns, proved very useful, and so did the Hurricane equipped to carry bombs.

Especially since Hitler invaded Russia, the R.A.F. has done all that it could to distract German effort from the East to the West. The daylight sweeps with fighter escort have been effective in achieving this object. In July there was evidence that most of the best German fighter aircraft had gone to Russia, and those left in France were reluctant to face our fighter escorts. As a result, the Blenheims could plant their bombs with little interference.

Two Curtiss fighters which have arrived in this country and the Middle East. The top picture is of the Allison-engined Kittyhawk which is a development of the Tomahawk shown underneath, taking off from a Western Desert airfield.





Two newcomers of 1941. (Top) The Vulture-engined Avro Manchester heavy bomber which has been used to drop many of the new blast bombs on German industrial centres. (Bottom) Britain's heaviest. The Short Stirling which is powered by four Bristol Hercules sleeve-valve engines. The Stirling has been used with great effect for both day and night raiding.

Gradually more and better German fighters were encountered, and sometimes R.A.F. losses exceeded those of the enemy. That was proof positive that the Russian airmen would meet with less opposition.

Then the production in numbers of heavier bombers, the Stirling, the Halifax, the Manchester, and the leased-and-lent Fortresses, enabled night raids to be sent further afield and heavier loads of bombs to be dropped on the targets. New bombs were produced which had five times the explosive power of those used at the beginning of the war. The four-engined bombers paid good dividends, for they proved better able to penetrate the German defences, and they suffered a smaller proportion of losses than did our earlier types. Last year, Air Force authorities called the Wellington "the best bomber in the world"; they now pay that compliment to the Stirling.

Once the *Luftwaffe* had begun to mass against the Balkans and Russia, the night raiding on Great Britain became sporadic. On May 10th there was a very heavy attack on London, in which the House of Commons was burnt out, and damage was done to Westminster Abbey, Westminster Hall, the British Museum, the Temple Chapel, and other buildings. After that, during the summer and the autumn, London was left alone, though there were occasional attacks on Liverpool, Manchester, Belfast, and other cities. All the time our defence was growing stronger. Radiolocation came into its own, and on the raid of May 10th no fewer than 33 German bombers were shot down, mostly by our night fighters.

Hurricanes, Defiants, Beaufighters, and Douglas Havocs were chiefly used by the night-fighting squadrons. Beaufighters and Havocs in particular would cross the Channel when a raid was on and wait over the French airfields for the return of the German raiders. A very satisfactory number of bombers was destroyed by these tactics, and the effect on the nerves of other air crews cannot have been good. All through the autumn it seemed clear that we were dealing with tyro crews who regarded simple raids on our coasts as a sort of training, but who rarely faced well-defended areas.

All through the year the Empire Training Scheme in Canada was growing more and more efficient, and large numbers of trained air crews arrived in Great Britain. Schools for training air crews and aircraftmen were established in other parts of the Empire as well, in Australia, New Zealand, South Africa, and Rhodesia; while in Great Britain training was pushed ahead with unremitting vigour. Britons were also trained in the United States.

In December, Japan attacked both the possessions of the United States and parts of the British Empire in the Pacific without waiting to declare war. That declaration came later, and then Germany and Italy also declared war on the United States. The Japanese opening blows were struck by aircraft carriers, and they were aimed in many directions. But it was the land-based torpedo-aircraft which sank H.M.S. *Prince of Wales* and *Repulse* off Malaya, and so upset the naval position in the Pacific. The Americans also lost two rather ancient battleships and some ships of less importance at Hawaii. Then the Japanese advanced down the Malay peninsula, and also landed at Hong Kong. As we go to press fighting continues.

So the year ends with a mixture of good and bad news. The Russians are doing famously—and perhaps that is the most important thing of all—though it is certainly of first-rate importance that we have been doing better of late in the Battle of the Atlantic and that the United States are now fully in the war against the three Axis Powers. In Libya the long-drawn-out battle is ending in our favour, and that may have very great results. In the Pacific things are not going so well at the moment, but still the combined naval power of the British Empire and the United States is far greater than that of the Axis. It can only be a matter of time before the tide in the Pacific turns in our favour. We look forward to 1942 with calm confidence.

Nineteenth of the Second Series

FRIEND or FOE ?

Twin-tailed D.H. Hertfordshire and Dornier Do 215

HERTFORDSHIRE : Egg-shaped outrigged twin fins and rudders. Tailplane tapers on leading-edge only. Non-retractable tail wheel.

USED principally on communications, the De Havilland Hertfordshire is the R.A.F. version of the Flamingo and is a particularly shapely aircraft, and although its tail assembly bears a general resemblance to that of the Dornier Do 215 bomber there should rarely be any risk of these two machines being confused with each other, even from a rear underneath view.

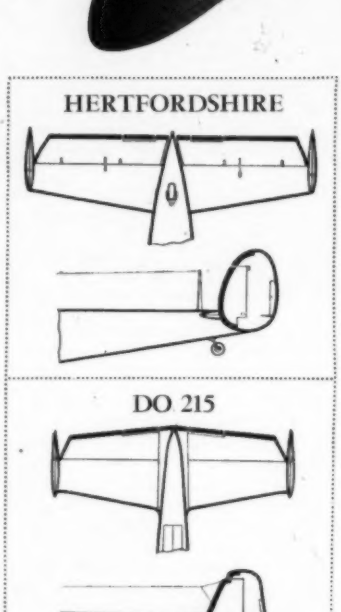
The former has a smoothly curving underside from nose to tail, whereas the latter's fuselage has a deeper forward section which houses a rearward-firing gun position. The wings of the British aircraft, also, are nicely tapered, while those of the Dornier have a more stumpy, blunt appearance. Both, of course, are of the shoulder-wing type.

The similarity between their respective tail units lies in the general layout. Both have quite normal aspect-ratio cantilever tailplanes which taper towards the tips; both have twin fins and rudders outrigged on the tailplane tips; both have pointed fuselage tails terminating approximately level with the trailing-edge of the elevators, and both have the outer tips of the elevators cut away on a straight edge to permit the requisite degree of rudder movement.

In fact, about the only really obvious structural difference is that the tail wheel of the Hertfordshire is non-retractable whereas that of the Dornier retracts completely when in flight.

This high degree of similarity in the main characteristics of the two tail designs gives all the greater importance, from the spotter's point of view, to such differences as do exist in various details.

The first to strike the eye, on looking at the accompanying drawings, will be the actual shapes of the respective fins and rudders; those of the Hertfordshire, it will be noticed, are approximately egg-shaped, but with more radius towards the lower portion of the leading-edge than on the trailing-edge. The small, rounded tip may be said to represent the narrower end of the egg.

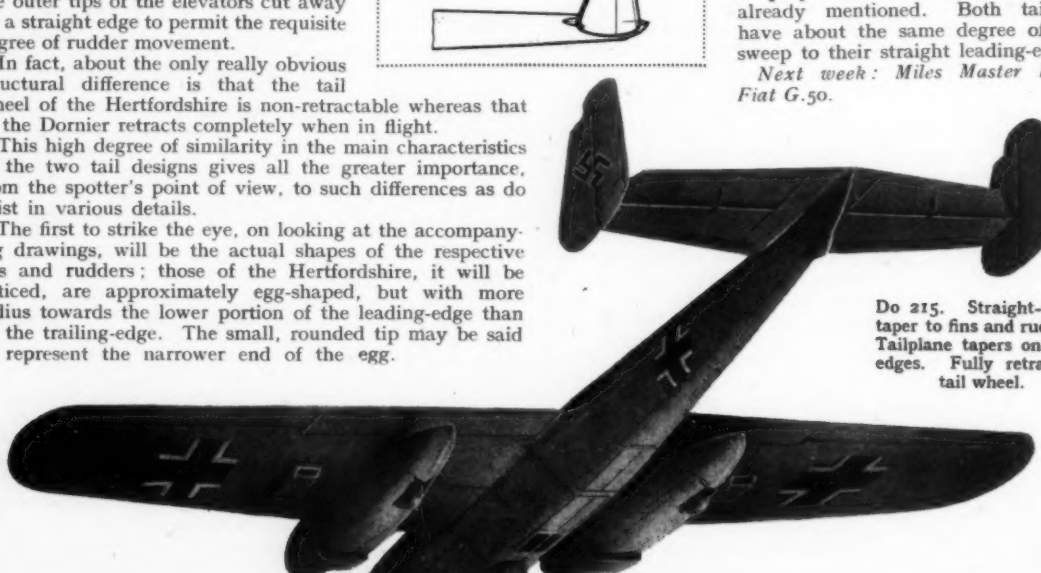


Now look at the Dornier's fin and rudder. This also tapers inwards towards the top, mainly on its leading-edge, but both edges are straight instead of curved; the apex and base-line, however, are wide-radius curves, and there is a small "step" near the top of the leading-edge formed by the abbreviated horn-balance of the rudder.

There is far less difference between the horizontal surfaces than between the fins and rudders of these two aircraft. The Hertfordshire tailplane is of somewhat greater aspect-ratio than that of the German machine, but this alone would not be a very quick or reliable means of identification.

What can be far more readily spotted, however, is the fact that the trailing-edge of the elevators on the Hertfordshire forms a straight line (broken only at the centre where the extremity of the fuselage projects very slightly) whereas that of the Do 215 tapers from the centre to the tips. True, the degree of taper is not very pronounced, but it will be a helpful indication when considered in conjunction with the other features already mentioned. Both tailplanes have about the same degree of back-sweep to their straight leading-edges.

Next week: Miles Master II and Fiat G.50.



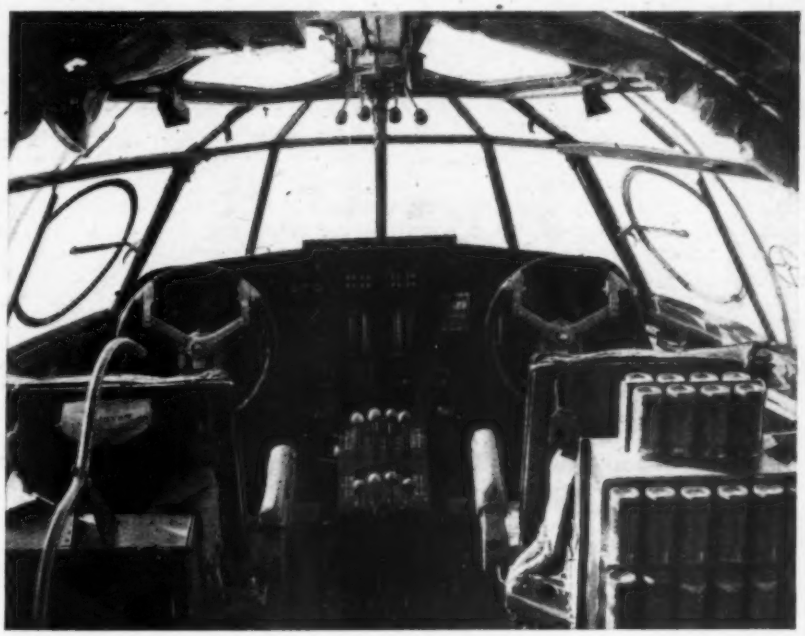
Do 215. Straight-edged taper to fins and rudders. Tailplane tapers on both edges. Fully retracting tail wheel.

OFFICES TO LET—OR HINDER (CONTINUED)

grab the right lever in time, or by his grabbing the wrong one. To this end I think the appearance and feel of the control is at least as important as its location.

The last few steps towards useful uniformity as opposed to ruthless standardisation: the action of all hydraulic levers should surely be the same. Some systems have two-position levers—the best I think; some have three positions, where the lever automatically returns to neutral; some have three positions, where the pilot has to bring the lever back to neutral manually—a 100 per cent. increase in his operations. One of these systems should be absolutely standard.

Feathering controls, however they work, should be fitted up to look and handle the same from the pilot's point of view, regardless of how they do their job. It would save tempers if the adjusting wheel on the rudder bar worked the same way on all aircraft, say, clockwise to lengthen. Flap and trim indicators, both the gauge and sliding-pip type, should have a standardised external appearance.



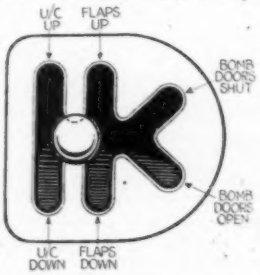
The roominess of Class 5 is typified in this photograph of a Short Sunderland cockpit. It is an example of particularly careful planning.

If all these suggestions were worked out, we should have the most nearly uniform cockpit layout which is necessary from the pilot's point of view and practical from the designer's angle.

There is quite a lot more that can be done, however, to simplify the production of complete aircraft by standardising components.

Too Great Variety

Such components as pilots' seats, seat-raising gear, adjustable rudder bar (both pedestal and hanging types) and trimmer controls, for instance, could surely each be reduced to two or three standard types which between them would cover the needs of all classes of aircraft. At present nearly every aircraft firm designs its own components and many firms do not even standardise them from one type to another of their own design; and the later designs are not always justified by improved results.



A suggested arrangement whereby a floating lever in a gate can be used for a number of operations.

The recently retired chairman of the S.B.A.C. was once inspecting a prototype aircraft in its early stages of building. He recognised the pilot's seat as the seat from a production aircraft of another type also designed and built by the same firm. His comment was, "Thank God, the seat is standard." He gave a very natural, but not repeatable, reason why the seat should be standard.

If junior draughtsmen could be weaned from their love of cunning "twiddly bits," and if some of the more easily standardised assemblies, such as those I have mentioned, could be handed over to specialists and the design finalised and frozen, the production people would have an easier time, the overloaded design staff would be relieved and many sets of jigs, and tools saved. Also unnecessary variation in cockpits would be reduced.

I have made no attempt to suggest any of the many improvements which might be made, such as having a floating lever mounted in a gate with four or more positions, thus making one lever work two or more hydraulic services, or having an electric constant-speed control mounted on the throttle lever so that both revolutions and boost can be controlled at will by one hand.

Uniformity of Detail

The purpose of this article is to persuade some pilots to modify their demands for standardised layouts and to be content with a measure of uniformity of detail, and at the same time to advocate the reduction of control handles to a standard pattern for each control and—for the productioneers—to bring the unnecessarily varied designs of the components I have mentioned down to the minimum number which can be made to suit all classes of aircraft.

There are at least four positions for the gear lever and four arrangements of the gear positions themselves on the common motor car. It is unlikely that we shall ever find levers on aircraft in exactly the same place from one type to another, but there is no reason why we should not expect to find them in corresponding zones, and one day any one control may be instantly recognisable on any type by its colour and shape.

TURBO-SUPERCHARGING

HOW POWER OUTPUT IS MAINTAINED AT HIGH ALTITUDES. THE BASIC PRINCIPLE EXPLAINED AND ILLUSTRATED

ALTHOUGH the development of exhaust-turbine-driven superchargers for aircraft engines has been proceeding for more than twenty years, success in production is of relatively recent date. Despite the technical interest of the subject it was at first regarded as somewhat futuristic and did not receive widespread attention. In the early days, of course, it was ahead of its time, and no demand existed for such equipment, as both aircraft and aircraft engines were only at a relatively low stage of development. Great credit is due to the pioneers who so ably visualised the needs of the next generation and continued their researches with little or no prospect of recognition or reward. To-day, as a result of the amazingly rapid increase in the powers, speeds and operating heights of modern aircraft, a genuine need exists for such a system of charging. In view of the relative paucity of available information it is understandable that a good deal of misconception exists on the subject.

Utilising the Exhaust Stream

Briefly stated, turbo-supercharging consists of fitting to the engine a high-speed turbine, which is driven by the impact of the escaping exhaust gases upon its rotor blades. This rotor is mounted on the same shaft as the impeller of a centrifugal blower, which delivers air under pressure through the carburettor into the cylinders of the engine. As the turbine is driven by the exhaust gases which, apart from a modest propulsive effect, are normally run to waste, it is not infrequently suggested that the power delivered by the turbine is obtained for nothing. The fact that this is not the case, as will be apparent later, does not detract from the striking advantages turbo-supercharging possesses for aircraft engines.

Primarily the object of any form of supercharging of an internal combustion engine is to force into the cylinders by mechanical means a greater weight of air, or combustible mixture, than would reach them under the influence of normal atmospheric pressure. It is essential to realise that a descending piston does not suck air into the cylinder through the inlet port. On its descent each piston tends to create a vacuum in the cylinder, and air from outside, under the influence of atmospheric pressure, flows in to fill the space.

"Nature abhors a vacuum." However, owing to the extremely limited time available, the impossibility of providing an unimpeded flow, pulsation in inlet system and expansion due to heat from the engine, the cylinder is never completely filled; never breathes in a complete lung-full. The ratio between the actual breath and the capacity of the lung is called the volumetric efficiency and usually is round about 80 per cent.

Obviously the power developed by an engine is dependent upon the weight of combustible mixture which enters each cylinder. Here it is compressed and ignited, the latent heat of the fuel is released on combustion, and the charge is rapidly expanded. This expansion drives the piston downwards, and the heat energy of the fuel is converted into mechanical energy. Theoretically, to get the utmost value out of this expansion it should be made to work until the gases have cooled to the original temperature and returned to atmospheric pressure. Limitations of the reciprocating engine and of the cycle of operations, however, are such that the exhaust gases are discharged at considerable temperature and velocity. To retrieve some of this waste energy has been the aim of engineers for years. The difficulty of doing so becomes apparent when it is appreciated that as the exhaust issues from the cylinder the heat and the rate of expansion are rapidly decreasing. Moreover, it must be noted that heat has no mechanical energy of its own; it has to be converted into energy. The virtue left in an exhaust blast as it reaches open air consists of rapidly falling heat, rapidly falling expansion, and a high velocity of particles comprising the same weight as the air and fuel which originally entered the cylinder before they were "fired." Hence the only mechanical energy contained by the free exhaust blast as such is the weight of the original charge which has been given a velocity from expansion and from the travel of the piston, and thus possesses a momentum. On a large aircraft engine this exhaust blast momentum may be considerable, although it is only a small part of the possibilities of the wasted heat as a potential energy maker. Free exhaust blast is not nearly enough to provide the motive power for driving a supercharger.

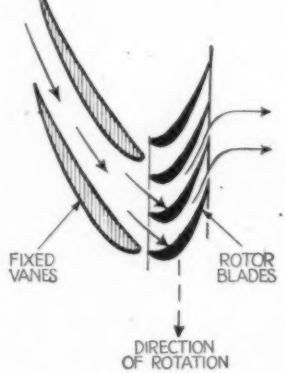


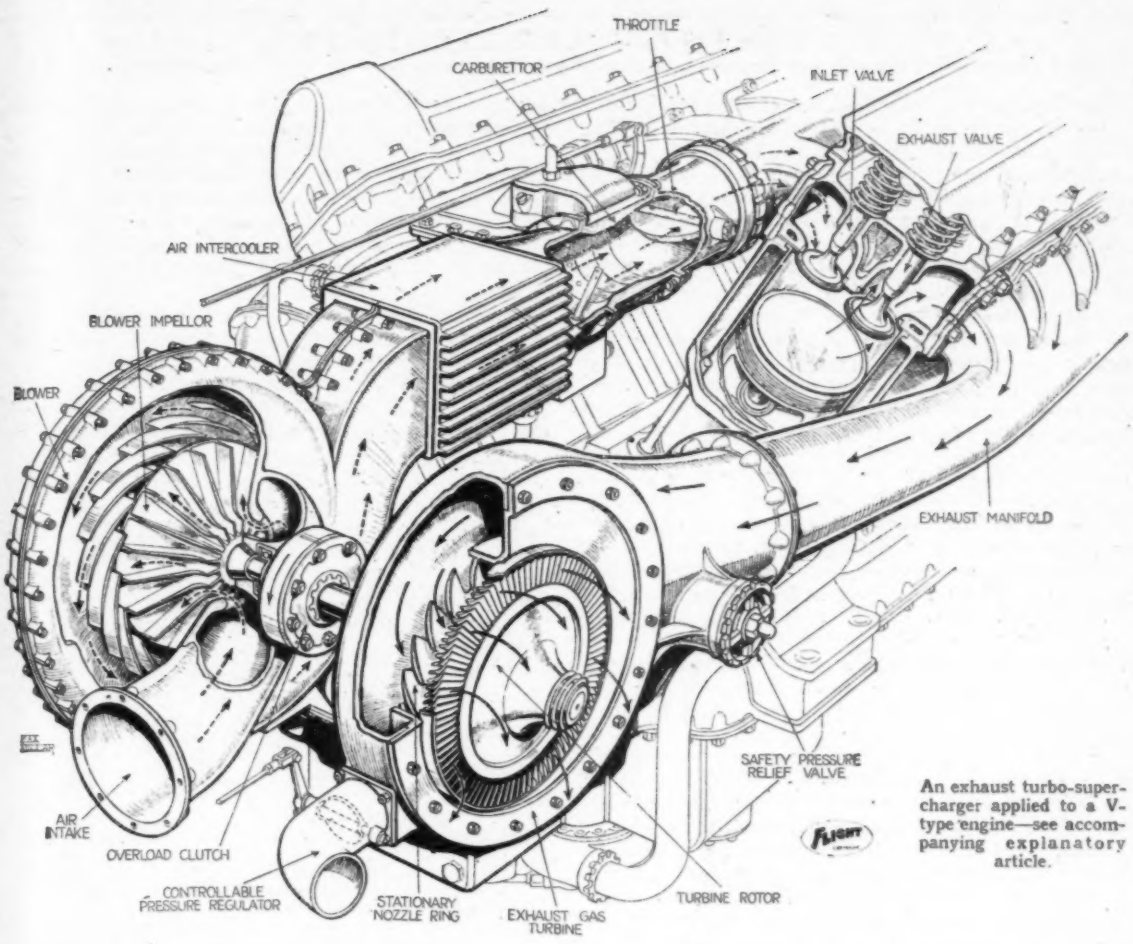
Diagram showing the path of the exhaust gas past the stationary guide vanes of the nozzle ring and the blades of the rotor before being discharged into the slipstream.

The Object of Supercharging

At this point the work of a supercharger may be studied. Its function is to force a certain weight of air into the engine, there to be mixed with a certain weight of fuel. It is the *weight* of air that matters, not the *volume*, since the volume varies with the pressure. Normal atmospheric pressure at sea level is at an average of 14.7 lb. per square inch, the equivalent being a barometric reading of 29.92in. of mercury, or 33.95ft. of water. The density of sea level air is 0.076 lb. per cubic foot, and the specific volume is 13.14 cubic feet per lb. Normal temperature is 62 deg. F. or 16.7 deg. C. Air at sea level comprises 23.6 per cent. oxygen and 76.4 per cent. nitrogen. The nitrogen passes in and out of an internal combustion engine as an inert gas, and does no work on its own account.

The ratio by weight of air to fuel lies between 9 : 1 and 17 : 1, with 14 or 15 : 1 about the figure to give the best efficiency of combustion.

It will be seen then that at atmospheric pressure a given weight of air will have a certain volume. At a pressure below atmosphere the same weight of air has a greater volume, above atmospheric a lesser volume. The power required to drive a supercharger of any kind is basically conditioned by the weight of the air it has to move.



An exhaust turbo-supercharger applied to a V-type engine—see accompanying explanatory article.

THE PRINCIPLE OF TURBO-SUPERCHARGING

AS the piston of an engine descends on the inlet stroke a partial vacuum is created in the cylinder and when the inlet valve opens, air from the surrounding atmosphere, which has a pressure of 14.7 lb. per sq. in., enters into the cylinder carrying fuel from the carburettor jets. This is "normal aspiration," and as the pressure of the atmosphere is substantially constant at a given altitude, a definite limit is imposed on the amount of air which can be drawn into the cylinder and consequently the amount of fuel which can be usefully consumed.

If the inlet air pressure is raised a greater weight of air will enter the cylinder, more fuel can be consumed and consequently more power delivered by the engine. An increase of pressure can be effected by a blower or fan driven by the engine, and this is the normal "supercharging" method. Of course, energy is needed to drive the blower and this reduces the power delivered by the engine.

The exhaust gases discharged from the engine have not given up all their energy. There is some kinetic or moving energy, some pressure and considerable heat which is another form of energy.

ON a turbo-charging system this hitherto wasted power is employed to drive the supercharging blower. The exhaust gas from the engine cylinders passes to the casing of a turbine and flows through a series of fixed vanes in the nozzle ring to give it a suitable direction to impinge on oppositely directed blades on the rotor. In passing through this second ring of blades the rotor is caused to revolve and the exhaust gas is discharged into the slip-stream flowing along the fuselage. The rotor is coupled either directly or with a suitable overload clutch to the impeller of a centrifugal blower which draws in air near its shaft centre and delivers through a series of fixed guide vanes to the volute casing from which it passes *via* the carburettor and the inlet manifold to the engine cylinders. As the air becomes somewhat heated, and consequently expanded, in its passage through the blower, a cooler may be provided between the blower and the carburettor in order that the weight of air entering the engine cylinder shall not be reduced.

IN the turbine the work is done by the expansion of the gases from a relatively high pressure back to atmospheric pressure. Obviously when the aircraft is operating at high altitude the "pressure drop" at the turbine increases as the atmospheric pressure decreases. As a result the turbine drives the blower at a higher rate of revolution and an increased volume of air is forced into the engine cylinder, maintaining the weight of the charge and thus avoiding a fall in the power output. This is the cardinal advantage of the turbo-supercharger for aircraft operating at extreme altitudes.

TURBO-SUPERCHARGING

The object of supercharging an engine is broadly this: The pressure produced by expanding or "firing" a charge of mixture depends upon two things, the weight of the charge and the compression to which it is subjected before firing. Obviously a large cylinder can accommodate a greater weight than a small one at the same compression pressure. On the other hand, the higher the compression the greater will be the pressure developed on the firing or expansion stroke, but there is a limit, according to the type of fuel employed, upon the degree to which compression can be raised, and if this limit be exceeded, detonation instead of smooth expansion takes place. If this were not so, higher powers from engines of given cylinder capacity could be obtained by using higher compressions, without supercharging.

Effect of Increasing Compression Ratio

Again broadly speaking, increased power can be obtained from cylinders of a given size by raising the compression, and thus the expansion pressures, or by increasing the number of expansion strokes which take place in a given time; that is to say, increasing the number of revolutions per minute. Or both methods can be combined, within reasonable limits. But the higher the engine speed, the less is atmospheric pressure able to give each cylinder a complete lung full of mixture. Because of the high velocities necessary past the various obstructions, such as pipes, ports and valves, the volumetric efficiency falls off.

The function of supercharging is to provide means whereby the requisite weight of air can be forced into the cylinder at the desired engine speed. The density of air at sea level is relatively low, hence a considerable volume at atmospheric pressure has to be moved in order to supply the requisite weight, and thus a supercharger has either to be of large size or run at a very high speed. To drive it necessitates considerable power, approximately 15 to 20 per cent. of the theoretical maximum power of the engine. So long as the supercharger is delivering the goods it will require that power to drive it, irrespective of the method by which the power is applied.

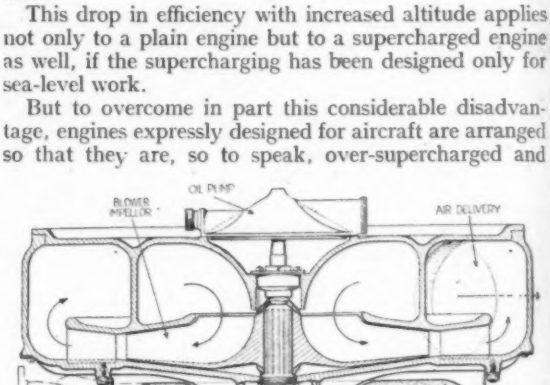
When a given brake-horse-power is required from an internal combustion engine there is a choice of two compromises. To use a large-size engine running slowly and obtaining its lungs full by means of atmospheric pressure alone, or to use a smaller engine running at higher speed, and provided with a supercharger to make sure that the lungs are filled completely. Practical limitations of design render the supercharged engine the better compromise for high-speed vehicles, or for aircraft, though there is a much more cogent reason regarding the latter, as will be seen when the story unfolds. The supercharged engine can be smaller in bulk, and more economical in weight.

Supercharging for High Altitude

So far the matter of supercharging has been outlined in only one phase; that is to say, the conditions which exist when the engine is operating at normal atmospheric pressure, or sea-level pressure. When the internal combustion engine is used on aircraft an entirely different set of conditions are encountered. The power developed by an unsupercharged engine becomes less and less as the aircraft mounts higher and higher, for the very simple reason that the air becomes less dense as the height above the earth's surface is increased. Atmospheric pressure at 20,000ft. altitude is half the figure at sea level, and the density is about 0.04 lb. per cubic ft. instead of 0.076 lb. Thus at this height the volumetric efficiency of the engine drops from 80 per cent. to round about 45 per cent. Each cylinder is only receiving about a half-weight charge. At 35,000ft. the air density is about one-quarter of the figure at sea level.

This drop in efficiency with increased altitude applies not only to a plain engine but to a supercharged engine as well, if the supercharging has been designed only for sea-level work.

But to overcome in part this considerable disadvantage, engines expressly designed for aircraft are arranged so that they are, so to speak, over-supercharged and



Turbo-supercharging is not confined to line type engines. Here is a section of equipment designed for a radial engine. The exposed turbine rotor is integral with the shaft which carries the blower impeller. To avoid the transfer of heat, a layer of thermal insulating material is provided on the turbine casing and air is circulated between turbine and blower and around the main bearings.

have too high a compression pressure for use at sea level. If they are allowed to operate at sea level with this condition unchecked they will more or less distintegrate, so they are prevented from using the surplus at sea level by controls which stop the throttle from being fully opened, and thus keep matters within the safe limit. As the aircraft gains altitude, the throttle can safely be opened wider and wider, and at the designed ceiling the engine is able to develop fair power. If it be desired to raise the maximum height still farther, the engine needs to be supercharged at a still greater rate, which can be done by fitting it with a two-speed gear drive to the supercharger, driving it at a higher speed for high altitudes, so that it is able to push into the engine a greater number of cubic feet of the less dense air and thus supply the necessary weight of air. Excluding mechanical losses due to the increased speed and the gearing, the supercharger will not require any more power to drive it at the higher speed in thin air than is needed at the lower speed in more dense air, because its job of work is the same at all times, namely, to move into the engine a certain weight of air in a given time.

This approach to the subject by reviewing the elementary considerations should serve to bring out the particular aim of turbo-supercharging. The aircraft engine is required to maintain its power output irrespective of

TURBO-SUPERCHARGING

height. This purpose may be achieved if the engine can be supplied with its full weight of air irrespective of the density of the surrounding atmosphere.

If the supercharger could be provided with an automatically variable gear which would drive it at higher and higher speeds as the aircraft climbed into the stratosphere, the main purpose would be achieved. This, to all intents and purposes, is just what the turbo-supercharger provides, with little or no addition of weight, minimum complication, and maybe with less loss of efficiency, since it gains something, possibly not a great deal, from a more or less wasted by-product of the engine, the exhaust blast. It is not providing something for nothing, but is doing a certain difficult job in an efficient manner. In fact, it represents a considerable mechanical advance.

The Exhaust-driven Turbine

Sufficient has been said of the blower or supercharger part of the installation to permit it to be set aside, and attention directed to the exhaust-driven turbine which provides the power for the blower. Issuing from the open exhaust of an engine is a pulsating blast of hot gases. This blast has the same weight as the charge which entered the engine and a velocity imparted to it by the pistons and by expansion in the cylinders. The heat still raging in it continues to keep it expanded far above the pressure at which the charge entered. Thus the free blast contains a certain amount of mechanical energy in the form of a mass of particles travelling at a considerable velocity. This energy may be considerable, but it is of short range, so to speak, if allowed to escape.

On the other hand, if the exhaust be prevented from escaping it can be made to give up some of its energy as useful work, and at the same time be employed to act as a flexible column or vehicle to transmit movement from the piston crowns to the blades of the turbine. In this last manner the engine can be tapped, so that a proportion of the total power which it is developing is devoted to driving the turbine.

The method of carrying out this scheme consists of providing a conduit pipe which encloses all the outflow from the exhaust manifolds of the engine and leading this conduit into an annular ring or nozzle box. One face of this ring has a series of radially disposed vanes set at an angle, thus providing ports from which the gases emerge at an angle. Immediately opposite this ring of ports or jets is situated the ring of inclined blades on the turbine rotor, which is caused to rotate by the impact of the mass of particles of the exhaust gases travelling at high velocity. The gases then discharge into the open air. On an extension of the turbine rotor shaft is mounted the impeller of the supercharging blower, which thus is directly driven at the same speed as the turbine. The delivery of air from the blower is led through an inter-cooler to the carburettor, and from the carburettor to the inlet valves of the engine. Regulation is effected by providing in the turbine casing a controllable valve which can be opened to allow a proportion of the exhaust to escape to the open air before reaching the rotor.

Automatic Regulation

With this simple explanation of the system in mind, a study of the automatic regulation of its work can be made. With the throttle wide open, the supercharger blows air and fuel into the engine cylinders, where combustion takes place and the resulting exhaust pressure drives the rotor of the turbine. The velocity at which the particles of the exhaust gases issue from the engine will depend upon the difference between the pressure within the exhaust manifold and the pressure of the free air outside. Consequently the speed of the turbine rotor will depend upon the same difference. If outside pressure is reduced, the turbine will run faster and drive the blower faster. Hence, as a machine fitted with a turbo-supercharged engine climbs higher into less dense air, the pressure outside the turbine decreases, there is an increased difference between exhaust pressure and exterior pressure, and the turbine runs faster. In turn, the blower is driven faster and, of course, delivers a greater volume of the less dense air, so that the weight of the combustible charge and therefore the exhaust pressure is maintained. The nett result is that turbo-supercharging can automatically provide sea-level air pressure in the inlet system of the engine irrespective of altitude. Practical limitations are, of course, imposed by mechanical considerations affecting the charging system, the engine and also the aircraft itself.

The Blower Drive

To make another point clear it may be recalled that the power required to drive a blower is governed by the weight of the air it has to displace in a given time. If the density of the air is lessened, the blower will displace a less weight of it in a given time provided that the speed of its drive is unaltered. In this condition it will take less power to drive it. Conversely, the same power will be able to drive it faster under this condition, up to the point where the supercharger is again displacing the original weight of air. This, of course, neglects possible losses due to increased speed. It explains why the turbine is able to drive the supercharger up to the necessary increase of speed with decrease of density at increased altitude.

Since the whole subject of turbo-supercharging engines for aircraft is by no means a new one, it may be wondered why a system with such obvious theoretical advantages has been so long in coming to fruition. The answer is simple, and a mechanical matter. It has taken a long time to produce a metal for the turbine blades which will stand up to the extreme heat of the exhaust and at the same time the centrifugal force due to the exceedingly high rotational speeds. Patient research work on the part of the General Electric Company of U.S.A. in conjunction with U.S. Army Air Corps was eventually successful in overcoming the main obstacles, and turbo-supercharging is now an accomplished fact for certain types of operational aircraft. Credit for the development is due in no small measure to Dr. Sanford A. Moss, a clever scientist now in his 68th year.

A Thirty-year-old Problem

The history of turbo-supercharging dates back for many years. As long ago as 1911 a certain Herr Reihm was granted a German patent for an application of the system to, presumably, a stationary engine. In 1917 a somewhat similar scheme, specifically for the power maintenance of aircraft engines at altitude, was put forward by M. August Rateau, who made successful experiments with an engine and dynamometer on a mountain top in France. During the 1914-18 war the interchange of information between the Allies led to experiments

TURBO-SUPERCHARGING

being conducted in this country and in America for the development of turbo-supercharging. During 1918 Dr. Moss, in America, applied the system to a Liberty aircraft engine. Normally the Liberty developed 350 b.h.p. at sea level and 230 b.h.p. at 14,000ft. Dr. Moss demonstrated that with his arrangement of turbo-supercharging it was able to produce 356 b.h.p. when tested on Pike's Peak at a height of 14,000ft. In 1920 a height of 33,000ft. was reached in a biplane fitted with this form of supercharging and piloted by Major R. W. Schroeder. For some years the development was applied chiefly to the attainment of height records, but from 1930 onwards turbo-supercharging began to appear in American Service machines.

The foregoing comments refer specifically to aircraft engines using petrol as a fuel. It is interesting to note, however, that on stationary, marine and railway locomotive diesel engines, turbo-supercharging has for some years been in practical operation and is now in wide commercial production. It is applied to engines from the relatively low to the highest power outputs. Apart from the railway applications where reduction of size and weight for a given power output is of prime importance, turbo-supercharging in these fields has been developed particularly to obtain greater output from an engine of given size at what is relatively a reduced cost. It has succeeded not only on its technical but on its practical economic merits. Similarly to the aircraft application it has, of course, been particularly suitable for both rail and stationary installations at high altitudes, for instance in the high plateaux of certain South American countries.

M. T.

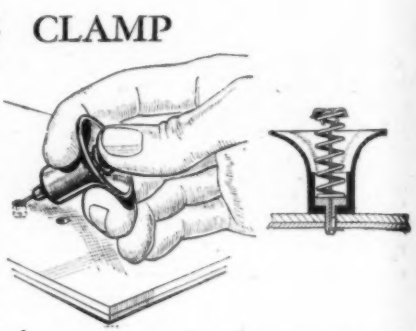
A SIMPLE LOCATING CLAMP

MANY ingenious devices for holding together two sheets of metal to be riveted have been produced. One of the latest is the "Van-Leer" panel and locating clamp. This simple fastener serves, as it name indicates, to locate positively, and hold in position, sheet metal panels prior to blind riveting, and it is claimed for it by its producers, Van Leer Auto Die-Castings, Ltd., that it eliminates all the disadvantages attached to other devices in the same field.

As will be seen by the accompanying illustration, this tool takes the form of a bell-shaped casting with a seating-centre some half-inch in diameter. From this seating there projects a hardened stud through which is passed a spring-loaded plunger. This is retained at the top by a dished cap forming the thumb-button for its operation, and at the business end by a flat hook to accommodate which the side of the locating stud is slotted.

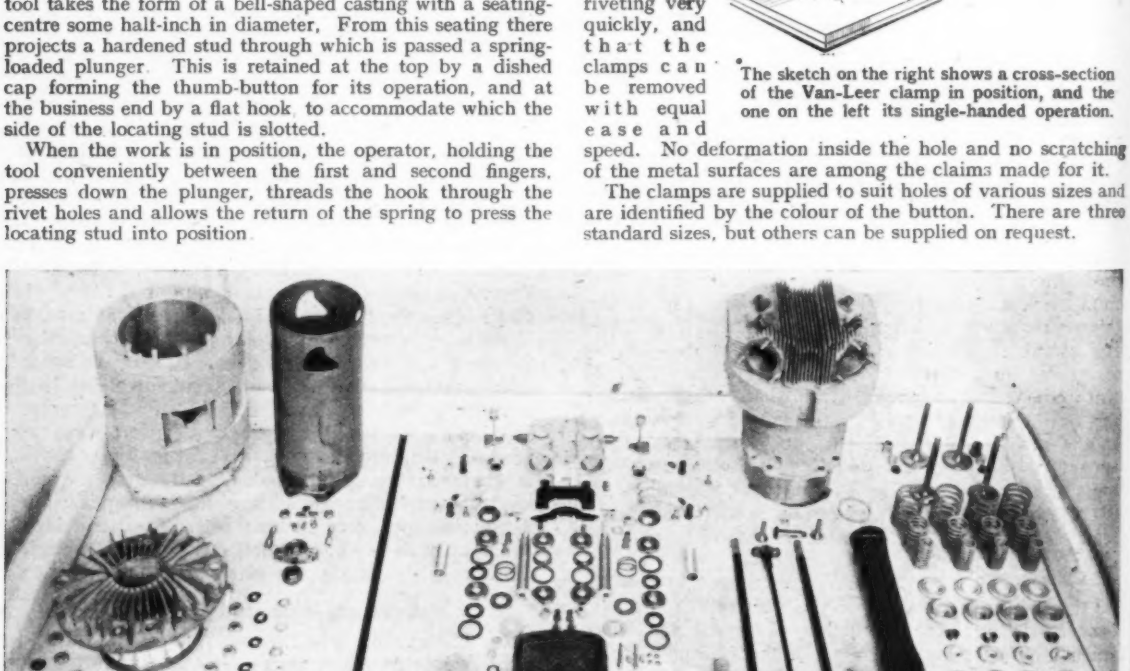
When the work is in position, the operator, holding the tool conveniently between the first and second fingers, presses down the plunger, threads the hook through the rivet holes and allows the return of the spring to press the locating stud into position.

It will readily be appreciated that this simple, single-handed operation enables the work to be set for riveting very quickly, and that the clamps can be removed with equal ease and speed. No deformation inside the hole and no scratching of the metal surfaces are among the claims made for it.



The sketch on the right shows a cross-section of the Van-Leer clamp in position, and the one on the left its single-handed operation.

The clamps are supplied to suit holes of various sizes and are identified by the colour of the button. There are three standard sizes, but others can be supplied on request.



FEW AND SIMPLE: In the article on the Bristol Hercules published in our issue of November 27th, 1941, the advantages inherent in the sleeve valve engine were enumerated. They included those of simplicity of parts and small number of parts. The claim is borne out by this photograph, which shows, on the left, the parts of a Bristol sleeve valve engine, and, on the right, the corresponding parts of a Bristol poppet valve engine.

HERE AND THERE

Astronomical Air Mileage

EASTERN AIR LINES began passenger service between New York City and Richmond, Va., on a daily-except-Sunday basis on August 18, 1930. From that date up to November 1, 1941, the company claims its aircraft have flown 690,000,000 passenger-miles, involving aircraft-miles equal to 3,440 trips around the world at the equator.

To-day, the "Silver Fleet" flies a total distance equal to more than two daily trips around the world at the equator.

R.C.A.F. Appointment

WING CDR. H. P. CRABB, a native of Leicestershire who emigrated to Canada as a youth and served in France with a Canadian regiment in 1915, has been appointed to the post of Director of Air Force Manning of the R.C.A.F., with the rank of Group Captain. The directorate is also responsible for pre-enlistment education and training.

Group Capt. Crabb is himself a veteran pilot, for in January, 1917, he transferred to the R.F.C. and, by the end of the war, was training instructors on Handley Page bombers. He resumed his flying activities in 1933, when he joined the Canadian Auxiliary Air Force with the rank of Flt. Lt.

S.B.A.C. Luncheon

THE American Ambassador, Mr. John Winant, was the chief guest at a luncheon of the Council of the Society of British Aircraft Constructors recently held at the Savoy Hotel. He was accompanied by Brig. Gen. R. Royce and Cdr. R. A. Ofstie. Among other guests were: Sir Charles Bruce-Gardner, Sir Frank Spriggs, Mr. C. V. Allen, Sqn. Cdr. J. Bird, Mr. R. Blackburn, Mr. E. C. Bowyer, Mr. H. E. Broadsmith, Mr. H. Burroughes, Mr. W. C. Devereux, Mr. H. R. Gillman, Mr. A. Gouge, Flt. Lt. L. M. Hilton, Mr. H. K. Jones, Maj. H. R. Kilner, Mr. E. Mensforth, Mr. G. H. Nelson, Mr. J. D. North, Mr. F. Handley Page, Mr. C. W. Reeve, Mr. W. E. Rootes, Mr. A. F. Sidgreaves, Mr. H. J. Thomas, Mr. A. Hessell Tiltman, Mr. C. C. Walker, and Sqn. Ldr. M. E. A. Wright.

Air-sickness Alleviated

AIR-SICKNESS experienced by many passengers on their first flights is being alleviated by administering a new medicinal mint-flavoured lozenge, Dr. Sam Bassett, of St. Louis (Missouri) told the convention of the aero-medical association of the United States, recently held in Boston.

The lozenges, about the size of a sixpence, contain amphetamine (benzedrine) sulphate and two other auxiliary chemicals. In the experimental use that has been made of the lozenge to date, said Dr. Bassett, stewardesses pass them out to passengers who exhibit nervousness before a flight, or give them to others who show signs of distress once the plane is underway. The results have been encouraging.

FAST AND TOUGH: Named after the sturdy, fleet-footed horse of the "Wild West," the North American Mustang shows its compact lines in this picture.

Anxiety "Evaporated"

HE said the lozenges, in medically controlled cases studied so far, produce "a feeling of well being, an evaporation of apprehension and anxiety, and they do it simply by overcoming the partial paralysis of the central nervous system that often results in nausea." Dr. Bassett added that the medicine tended to "tone up the brain and the reflexes" of the passengers.

And Dr. D. B. Dill, of the Harvard Fatigue Laboratory, in discussing Dr. Bassett's report, offered a corollary. He said that a relatively small dose of the same chemical was given a group of Harvard students before they took an examination.

"They reported," smiled Dr. Dill, "that ideas came to them faster than they could write them down."

It's a Fact!

THE crew of a Coastal Command Blenheim aircraft, bound for Norway, took a Norwegian officer with them.

As the Blenheim approached the coast the Norwegian shouted to the R.A.F. navigator, "Leave it to me now." He began to demonstrate the advantages of local knowledge.

A mountain loomed up ahead; and the pilot pulled back the stick and began to climb.

"No, no," cried the temporary navigator. "Go down."

Somewhat doubtfully the pilot obeyed. When he was low over the water he received further instructions . . . "Right . . . Left . . . Left again."

So the aircraft was taken over occupied territory without being spotted. In and out of fjords and round the sides of mountains flew the Blenheim in response to the Norwegian's commands; "Up, down, right, left."

When the aircraft returned to base the R.A.F. navigator summed up the Norwegian's performance by declaring, "He had me completely lost. It was a wizard show; but I was disappointed when he didn't take us up the main street of Bergen and tell us to pull up at the traffic lights."

Suspended Air Mail Services

THE Postmaster-General has announced that the air mail services by way of the United States of America and the trans-Pacific air service to Australasia, Burma, Ceylon, China, Dutch East Indies, Hong-Kong, India, Malaya, and the Far East generally (postage rates 3s. to 5s. per half-ounce) have been suspended.

Air mail correspondence for the countries concerned, prepaid at the rate of 1s. 3d. per half-ounce (China, 1s. 6d.), will be forwarded by the normal air mail route via South Africa.

Flew with his Back Broken

FOR 17 weeks visitors to Fighter Command's top-scoring station have been unaware that the Group Captain Station Commander has been carrying on his normal duties with a broken back.

Now that he is completely recovered, the plaster-of-paris in which he has been encased has been chipped off, but while he was encased in it, he did not allow it to stop his flying.

The Group Captain, who is 35, was taking off with squadrons from his station for an offensive sweep during August when the engine of his Spitfire failed and he crash-landed outside the airdrome and broke his back. He was taken to hospital, where it was found that with care, the bones would knit together. The plaster-of-paris was then put round him and he was so keen to get back to his job that he was on his station again within a week.

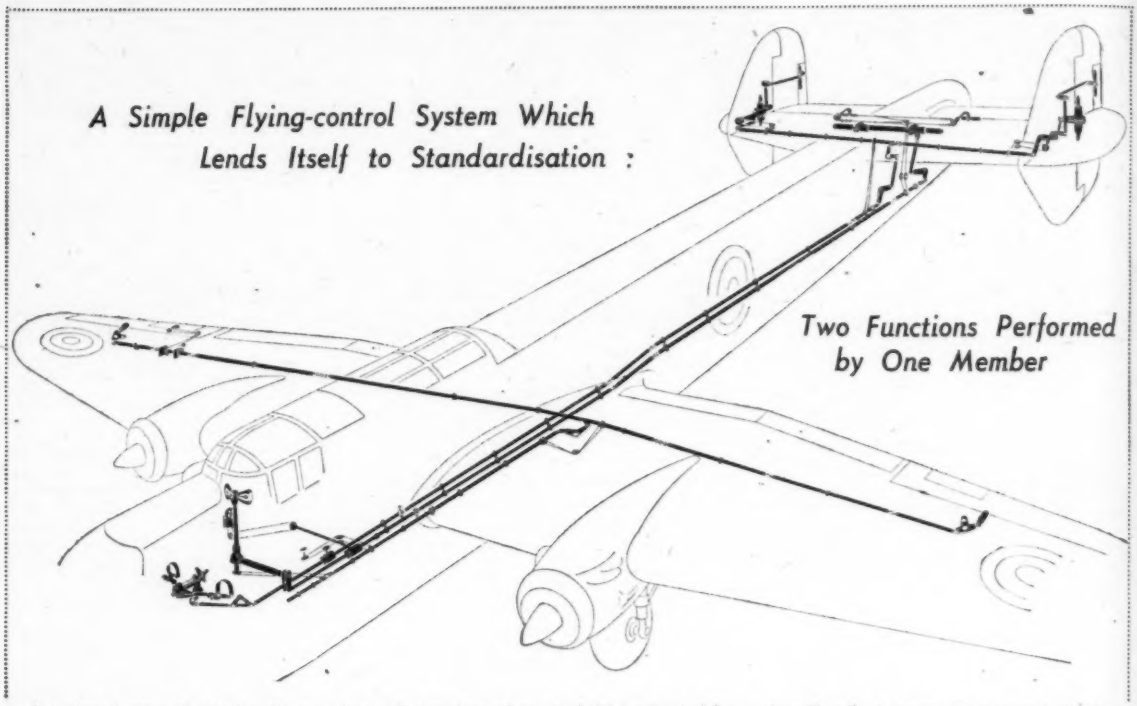
Later he went to an R.A.F. hospital for about a fortnight and then returned to his work—still with his back in plaster. By the latter half of September he was again flying his Spitfire on local patrol "just to keep his hand in."

This Group Captain, who is one of the youngest in the R.A.F., won his D.F.C. early in the war for gallantry in action.

ADVERTISED GOODS

THE fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

BY TUBE ALL THE WAY



A typical layout of the Saunders control, with main surfaces and tabs operated by push-pull and rotary movement respectively.

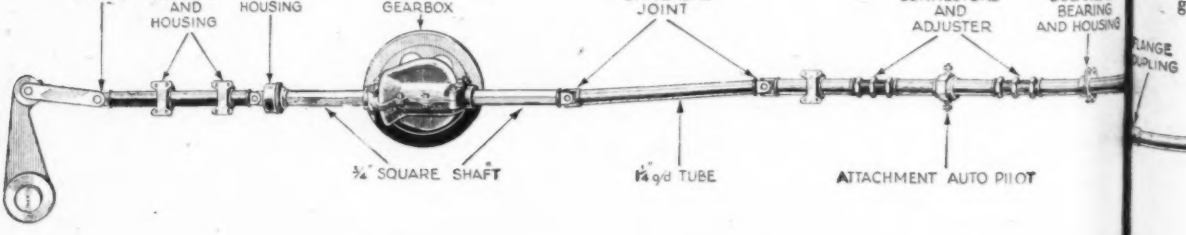
THE earliest aircraft had the pilot's control members connected to the control surfaces, such as elevator, rudder, wing warp or ailerons, by stranded steel cables. That was scarcely surprising, for the cable combined simplicity with low weight and great strength. Some of the pioneers used single controls for the ailerons. On the early Henry Farman "box kites," for example, a single cable ran from the joy stick to the underside of the aileron, and this control surface used to hang down limp, with the control cable slack, until the machine had gathered enough speed for the air to lift it into flying position. The next step was to add a return cable, which held both ailerons up even when the aircraft was stationary. In flight, one aileron moved up from the neutral position when the other was pulled down. That meant but a slight complication, and the system of operating all controls by cable remained in use for very many years.

Even after the aircraft itself was refined by streamlining it was customary to leave the control cables on the outside, particularly those to the rudder and elevator. Sometimes they ran inside the fuselage to a point near the tail, where they came out into the open to be connected to the cranks of their respective control surfaces. This had the advantage of accessibility for servicing, but it also meant that wear was excessive, for dust and grit would get into the guides and wear away one or more strands of the cable, and a constant watch had to be kept for frayed control cables. Another disadvantage was that, no matter what precautions were taken to pre-stretch the cables, they *would* stretch, and frequent adjustments of the turnbuckles were necessary.

Lack of Standardisation

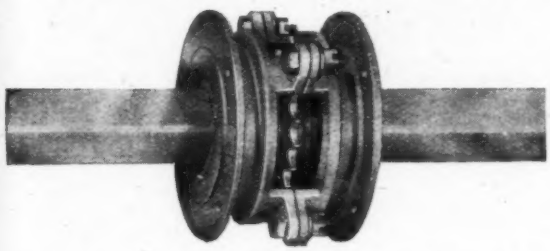
Since those early days every designer has had his own ideas of how flying controls should be arranged. In some of the earlier flying boats a simple push-pull system of tubes was used with fairly good results, but nothing like standardisation was achieved, nor even suggested, so far as we remember. Other control systems came along, and some were very ingenious. The majority came to be used for controls other than flying controls, such as for throttles, flaps, trimming tabs and undercarriages.

Recently a system has been introduced for the main flying controls which appears to have the advantage of simplicity, low weight and robustness. Known as the Saunders flying control, it has been approved by the Air



Ministry and is handled by Brown Brothers (Aircraft), Ltd. Briefly stated, the Saunders control system is a simple tubular push-pull arrangement, such as has been used by many designers for years past, but with the added feature that the main push-pull tubes can be rotated, the rotary movement being available for operating a second control surface. One obvious application is to the elevator, the longitudinal movement being used for operating the main control surface, and the rotary movement for changing the angle of the trimming tab.

In small aircraft there may be no need for tabs, and in that case the rotary movement may be employed for operating a main control surface, such as the rudder or elevator. In this connection, the first objection which comes to mind is the problem of harmonising the controls, so that the force which the pilot has to exert is approximately the same for both. This has been provided for in the scheme by the use of gear boxes, main and auxiliary, the suitable choice of which at the pilot's end and at the end nearest the control surface determines not only the load on the pilot's control but the torsional load in the control tube.



In the auxiliary gear box the rotary movement is imparted by chain and sprocket.

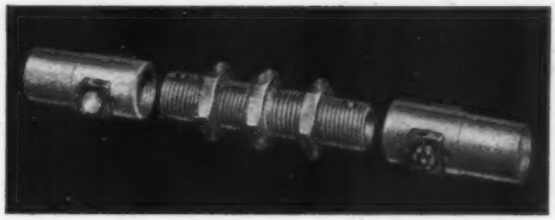
One of the advantages of the plain push-pull tube control as fitted originally was its lightness of operation. Usually the tube was simply hung on a crank arm at each end, and frictional resistance was very small. Obviously in a system in which the tubes have also to rotate, this simple arrangement cannot be used. One of the fundamental features of the Saunders control is that the tubes are carried in stabilising bearings. These are designed with conical seatings to accommodate deflections.

Allowing for Rotation

At the extreme ends of the control tubes are special swivel housings to which are attached swinging links for connection to the control cranks. These swivels are made necessary by the fact that the control tubes have to rotate.

Where a change in direction of the control run is necessary, universal joints may be installed, or subsidiary gear boxes which will allow changes of angle up to 90 deg. Couplings used are of two sorts: a sleeve type and a flange type. Adjustment between the pilot's control and the surface to be operated is effected by special adjusters having left-hand and right-hand threads. Finally there can be incorporated in the control tubes special transmission fittings for coupling to the automatic pilot.

Turning now to the feature which is the *raison d'être* of the Saunders control system, the rotary movement, this is imparted to the tubes by either a main or an auxiliary gear box. In either case a length of square rod runs



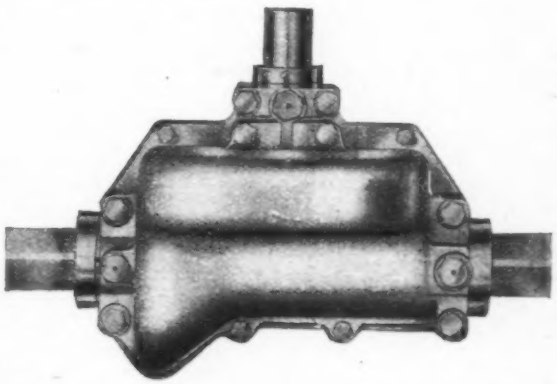
Vernier adjustment between pilot's control and the control surface is effected by this type of adjuster.

through the centre of the gear box, the length depending on the degree of linear movement required in any particular type of aircraft. The main gear box has machine-cut bevel gears housed in a casing of light alloy, the standard reduction ratio being 2 : 1. The gear box may be fitted either horizontally or vertically, and on the port or starboard side. In all cases the gear box is, of course, attached to the aircraft structure and allows the square-section rod to slide through it. The auxiliary gear box is somewhat simpler and consists essentially of a sprocket and its mounting, a chain being used for rotating the sprocket and thus the square-section rod.

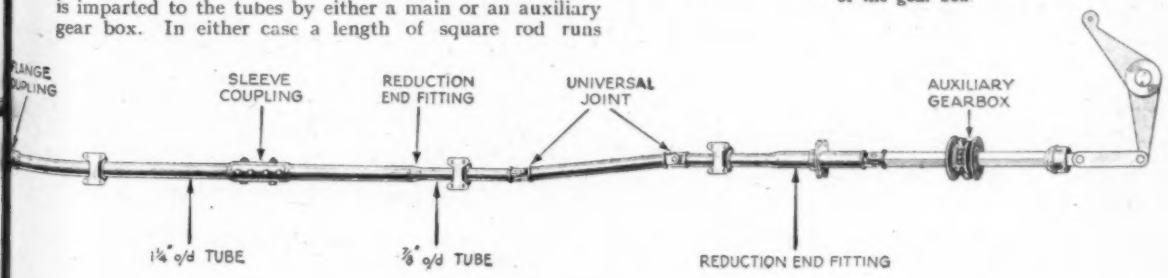
The words gear box rather convey an impression of weight. That this is not excessive is indicated by the fact that the main gear box weighs only 3 lb. 8 oz., while the auxiliary tips the scales at 15 oz. only.

It is recommended that for long control runs the distance between stabilising bearings should not exceed 40in. to 45in., based on operating loads in push-pull up to 1,000 lb. Normally the control tubes should be 1¼in. O/D × 20 S.W.G. aluminium alloy, but where there is a change of angle approaching 8 deg. the makers prefer that 1¼in. × 20 S.W.G. mild steel tube should be used.

Full particulars of the Saunders flying control are contained in an illustrated brochure, copies of which can be obtained by designers and others in responsible positions upon application to Brown Brothers (Aircraft), Ltd., Great Eastern Street, London, E.C.2.



The main gear box has bevel gears and a 2 : 1 gear ratio The square-section shaft is free to slide through the body of the gear box



Correspondence

The Editor does not hold himself responsible for the views expressed by correspondents. The names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.

BARREL ENGINES

A Reader Seeks Enlightenment

BEING another young member of the aeronautical fraternity, I was rather intrigued by E. S. Hall's fine articles on barrel engines (*Flight*, November 27th and December 4th). Much of the text is very clear, but there is just one point that some kind person, perhaps, could clear up. How is the piston motion transmitted from the wabbler arm to the shaft?

If the wabbler arms are arranged radially round the shaft, surely there could be no piston movement at all. Not being an engineer, the drawings were naturally rather complicated to my mind, but, try as I would, I could not construct a perspective drawing that would explain to me how the shaft is turned without a general bending or tangling up of the arms connecting the piston with the shaft.

Flight certainly is doing a great job of work for British aviation and is far ahead of all competitors.

CYRIL M. ROWLAND.

A.T.C. SQUADRONS

Stifled by "Committee Complex"

REFERRING to my letter, "A T.C. Squadrons," published in *Flight* of December 18th, I feel I should qualify my comments appertaining to gliding. An embarrassing coincidence is caused by the release of information in the *A.T.C. Gazette* revealing the steps actually being taken in this direction. This is worthy of the utmost support from those in a position to help.

My remarks were, in fact, merely a reiteration of a policy I have continuously advocated on every occasion when I have contacted cadets or instructors and even the lay Press. On receiving my December *Gazette* (a fortnight after writing to *Flight*) I realised that this information was indeed a 100 per cent. vindication of the case for gliding as presented.

I still maintain, however, that a "committee complex" stifles the natural expressions of the cadet movement, as it has done everything else in this war so far. Is the selection of committee members always made as carefully as it might be? As the A.T.C. is primarily a youth organisation, I believe that it should have a certain minimum of control in its own administration. Is it not a fact that it is solely the younger generation that has saved us, in spite of the blunders of older men?

I wonder how many of the organisers' ages are below even a very modest 40 years? Hence I fail to see how any committee can be truly representative of youth without at least one junior member to protect its highest ideals.

These committees are not demi-gods of officialdom, but merely co-opted private citizens, too often lacking in initiative and energy. It is the duty of Rotary Clubs, Education Authorities, Parents' Associations, and the local Press to see that our lads are not imposed on and that everything which can be done must be done to help them.

In conclusion, please realise that our social system considerately decrees that at the age of 19 or so they shall be fit to give up everything for us, even to die for us.

Honestly, are WE doing enough?

G. A. CHAMBERLAIN.

RANGE AND FUEL ECONOMY

Flaps in Relation to Power and Safety

IN an article in *Flight* of December 11th, 1941, Mr. C. L. Hinings attempts to set aright various erroneous statements made by a previous contributor, "Jinair," in *Flight* of September 18th, but in doing so falls into further error himself in saying that flying at the best L/D figure will give maximum duration.

As, in level flight, the lift is constant, flying at maximum L/D means flying at the speed at which the drag is at its minimum. But it is fuel consumption per hour, and therefore the speed of minimum *power* required, not minimum drag, that will give the greatest endurance. The minimum value of power required is realised when the drag multiplied by the speed is at its minimum figure, which occurs at a speed considerably lower than that of maximum L/D, usually proving to be little higher than stalling speed. Thus, the criterion for duration is the maximum value of $L^{3/2}/D$ not L/D.

Mere duration has little commercial value, and has received less and less attention from stunt flyers in recent years, probably due to the fact that endurance records are no longer officially recognised as records by the I.C.A.N. But it assumes importance in certain branches of military flying, and it is therefore desirable that any misapprehensions should be cleared up.

The case of a bomber circling its base waiting for a ground fog to clear, or the case of a fighter on patrol over an important target area provide two instances of occasions on which minimum fuel consumption is the critical factor.

The problem of the minimum power required for level flight assumes even greater importance in the case of the performance of a twin-engined aircraft with one engine out of action. If the remaining engine is not giving full power, or icing conditions have been encountered, the aircraft may be unable to maintain level flight. This introduces the problem of how to increase $C_L^{3/2}/C_D$ in case of emergency, and thus reduce the power required, as it is this factor which also governs the rate of climb and ceiling under these conditions, either of which may be the vital factor in bad weather or in mountainous country.

In a paper read before the Society of Automotive Engineers a year or two ago, Mr. Harlan D. Fowler, who developed the flap which bears his name, stressed that one of the main advantages of this type of high-lift device was its value as a "spare wing" in case of emergency, when the aircraft is endangered by severe icing or loss of power.

It is here that the distinction between the best L/D and the best $L^{3/2}/D$ shows its greatest importance. Extending a flap of the Fowler type will considerably reduce the maximum L/D, but it will considerably *increase* the maximum $L^{3/2}/D$, causing it to occur at a lower speed with consequent reduction in power required.

Thus, flaps of this type are not only of value for both take-off and landing, but provide an important additional safety factor in level flight.

This type of flap, of which the Fowler and Youngman are the best known examples, provides a large increase in lift as well as drag, and is thus of far greater value in this respect than the plain split flap, but N.A.C.A. tests show that even the split flap will provide an improvement in $C_L^{3/2}/C_D$ and increase the rate of climb and ceiling of a twin-engined aircraft when flying on one engine.

By far the best results were obtained with the N.A.C.A. Venetian blind flap, which shows both a very high C_L and a higher L/D than other types, so that apart from its other advantages, this form of flap appears worthy of development for its value as a "spare wing" alone.

Another respect in which flaps become important in level flight is in improving the manœuvrability of aircraft handicapped by high wing-loading. The minimum radius of turn depends on the speed at which stalling occurs, and is thus directly dependent on wing-loading. By extending flaps of the Fowler or N.A.C.A. type, the pilot can greatly reduce his stalling speed with consequent reduction in his minimum turning circle.

The most obvious application of this principle is in enabling a single-seater fighter to be built with the high wing-loading necessary for very high speed and yet at the same time able to retain the manœuvrability associated with much lower loadings. In view of the paramount importance of these two conflicting qualities, and the difficulty of effecting any compromise between them, it is somewhat surprising that development on these lines has not already reached a more advanced stage.

This use of flaps for manœuvring is likely to spread even further with the continued increase in wing-loading in all types of aircraft. It will, for instance, enable heavily loaded air liners to manœuvre at a lower safe speed when approaching landing grounds, and Mr. Clarence Johnson, chief research engineer of Lockheed Aircraft, has predicted the use of flaps in this manner for all low flying in future.

ROGER TENNANT.

Service Aviation

Royal Air Force and Fleet Air Arm News and Announcements

Civil and Service Pay

PRIVATE firms and public bodies who make up the pay of former employees serving in the Royal Air Force or the W.A.A.F. will, under a new procedure, be able to ascertain from the Air Ministry the amount of service pay which their employees get on entry for the purpose of assessing the balance of civil pay. Hitherto no formal official machinery has existed to furnish this information.

The new procedure is described in detail in a memorandum which is being sent to all employers who are known to be interested. Employers who do not receive a copy of the memorandum should apply for one to the Air Ministry, Accounts 15(B), Stroud, Glos.

University of London Degrees

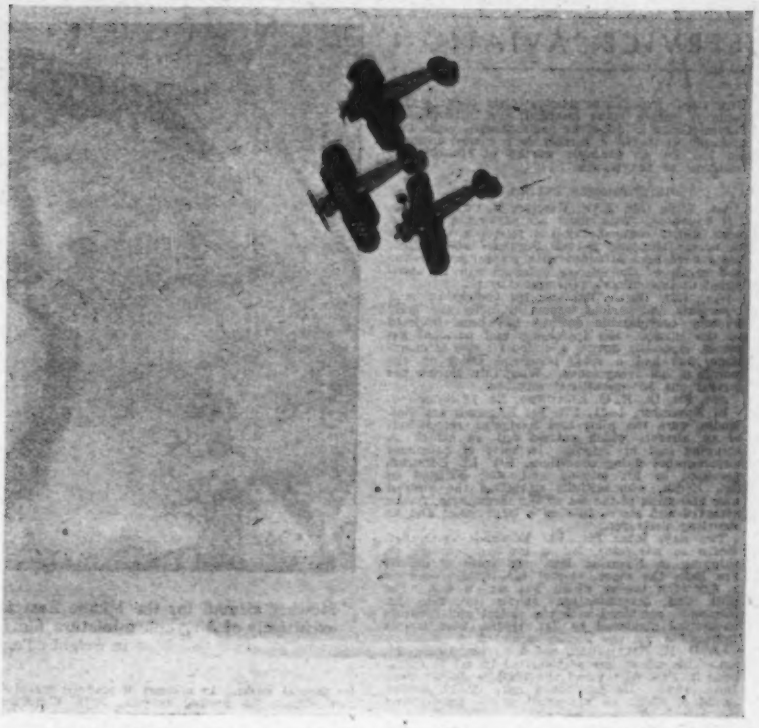
FACILITIES have now been arranged for R.A.F. and W.A.A.F. personnel to take degrees or diplomas as external students of the University of London.

Preparation will be by private study or by correspondence course, and, naturally, some subjects are more suited than others. The degrees and diplomas obtainable are:—

Degrees in theology, arts, laws, music, medicine, dental surgery, pharmacy, science, agriculture, horticulture, veterinary science, engineering, mining and metallurgy, economics and political science, commerce, estate management.

Diplomas in theology, geography, education, public health, clinical pathology, biology, public administration.

Advice and guidance—including reading lists for students for whom suitable educational facilities are not available—is obtainable from the University of London.



PRE-WAR MEMORY: At the 1936 R.A.F. Display at Hendon, Flt. Lt. H. Broadhurst, F/O J. R. MacLachlan and P/O B. G. Morris delighted the crowd with their flight aerobatics on the Gloster Gauntlets of No. 19 (F) Squadron. Flt. Lt. Broadhurst is now a Group Captain and has been awarded a Bar to his D.S.O.

Awards

THE KING has been graciously pleased to approve the following awards in recognition of gallantry displayed in flying operations against the enemy:—

BAR TO THE DISTINGUISHED SERVICE ORDER.

Act. Grp. Capt. H. BROADHURST, D.S.O., D.F.C., A.F.C.—This officer has organised and led his wing with conspicuous gallantry and success. During a heavy engagement over Bethune, in June, 1941, Grp. Capt. Broadhurst's aircraft was hit by a cannon shell which, besides making a large hole in the port wing, put the port wing guns out of action and also damaged the aileron, thus making control difficult. A second shell hit the side of the fuselage, causing havoc in the cockpit. Grp. Capt. Broadhurst received many small wounds in the arm and legs and only recovered from the effects of the shell-fire at 1,000 feet over the target area. Nevertheless, he flew the aircraft back to England. Within a few days, Grp. Capt. Broadhurst was again leading the wing in action over Northern France. On the return journey, he was attacked by a force of six Messerschmitt 109s, but by brilliant tactics Grp. Capt. Broadhurst fought them off and, it is believed, destroyed two of them before the engagement was terminated some 15 miles north of Gravelines. Although his aircraft was damaged by the enemy's fire,

PORTABLE RUNWAY: The U.S. Army Air Corps using a "Marston Strip" runway which is composed of sections of metal gratings hooked together and laid on a roughly-graded surface.

SERVICE AVIATION

Grp. Capt. Broadhurst flew it safely back to this country. Since being awarded the Distinguished Service Order in June, he has destroyed eight and probably destroyed a further four enemy aircraft. He has set an example worthy of the highest tradition of the service.

DISTINGUISHED FLYING CROSS.

Act. Wing Cdr. E. S. BARNES, R.A.F.V.R., No. 107 Squadron.—This officer has performed splendid work whilst commanding the squadron. Attacks on enemy shipping in the Benghazi and Tripoli areas have been attended with magnificent results and much of the success obtained can be attributed to this officer's skill and courage.

Wing Cdr. Barnes has also led attacks on road transports and various targets in Sicily and Italy whereby considerable damage has been inflicted on the enemy. His leadership and personal example, especially during a difficult phase of operations, has had a most beneficial effect on the morale of his flying crews. Wing Cdr. Barnes has carried out 35 operational missions.

Act. Flt. Lt. E. G. EDMUNDS, No. 18 Squadron.—In November, 1941, Flt. Lt. Edmunds and Sgt. Hedin were the pilot and navigator respectively of an aircraft which carried out an attack on shipping east of Tripoli. In spite of extremely unfavourable flying conditions, Flt. Lt. Edmunds persisted in his mission and, ably assisted by Sgt. Hedin, who skilfully navigated the aircraft over 200 miles of the sea to the target area, finally attacked and scored hits on a large vessel and an escorting destroyer.

Two days later Flt. Lt. Edmunds, with Sgt. Hedin as navigator, led a low-flying attack on shipping in Navarino Bay. In spite of intense fire from the shore, several hits were scored on a 6,000-ton tanker which was set on fire. The skill and determination shown by Flt. Lt. Edmunds, combined with the skilful and accurate navigation displayed by Sgt. Hedin, were largely responsible for the success achieved.

Lt. D. H. HILLHOUSE, S.A.A.F., No. 12 Squadron.—This officer has participated in active operations in East Africa and the Western Desert since June, 1940. He has taken part in 77 sorties, on 56 of which he has acted as air gunner and the remainder as bomb aimer. His ability to bomb his target accurately has been exceptional, and has contributed materially to the successes achieved by his unit. Lt. Hillhouse has shown great courage.

P/O. L. A. VAUGHAN, R.A.F.V.R., No. 148 Squadron.—This officer air-gunner has participated in 54 raids, including 28 against targets in Germany and German occupied territory. Throughout, he has displayed the utmost keenness for operations which, together with his utter contempt for danger, has set a splendid example to all.

On one occasion during a mine-laying mission, his aircraft was subjected to fire, at close range, from two anti-aircraft guns. By silencing these guns P/O. Vaughan performed very valuable work in difficult circumstances. As a qualified gunnery leader, he carries out a great deal of the instruction of new crews, a work in which he has shown real ability.

P/O. M. P. WAREHAM, R.A.F.V.R., No. 73 Squadron.—This officer has been engaged on operational flying in the Western Desert for the past ten months. Throughout a difficult and arduous period, he showed remarkable keenness for operations whatever the conditions or the odds. At one period he consistently operated with his unit from an exposed aerodrome at Tobruk for several weeks. In a series of planned machine gun attacks on ground targets, P/O. Wareham displayed exemplary coolness and initiative. He has destroyed at least three enemy aircraft off the Libyan coast.

Stowing airmail for the Middle East aboard a flying boat. It is composed almost exclusively of Airgraph miniature films which means a saving of over 98 per cent. in weight as against ordinary mail.

DISTINGUISHED FLYING MEDAL.

Sgt. S. E HEDIN, No. 18 Squadron.

For citation see Flt. Lt. Edmunds in previous column.

Sgt. F. C. ASTLEY, No. 615 Squadron.—This airman has carried out a large number of operational sorties, involving interception and convoy patrols. He has also participated in numerous highly successful attacks on enemy shipping, during which several enemy ships were set on fire and others damaged, and attacks on ground targets in Northern France. As a section leader for the past three months, Sgt. Astley has taken an active part in the training of new pilots, a task in which he has shown great keenness and devotion to duty.

Sgt. R. B. BIRTLES, R.A.F.V.R., No. 118 Squadron.—This airman has participated in a large number of sweeps and reconnaissances; he has also taken part in three attacks on enemy shipping and four on land targets when trains, factories and other objectives have been attacked. In November, 1941, during a sortie, Sgt. Birtles silenced a light anti-aircraft gun which was firing on his section leader.

Some days later he participated in an attack on a railway station in France. On the return journey one of his fellow-pilots was shot down into the sea. Sgt. Birtles, with great initiative, flew down to almost sea level, and while operating his aircraft controls with the right hand only, detached his own dinghy and so skilfully manœuvred his aircraft that he succeeded in dropping the dinghy within a few feet of his comrade, who was then swimming in the sea. Sgt. Birtles then flew on to his base, which he reached with very little petrol in the tanks.

Sgt. R. C. FINN, R.A.F.V.R., No. 615 Squadron.—This airman has participated in a large number of operational sorties, consisting of interception and convoy patrols. In addition, he has taken part in 43 attacks on enemy shipping and ground targets in Northern France. In the course of these attacks six ships, of various types, have been destroyed, two set on fire, and five damaged, whilst on land a transformer station and a factory were badly damaged.

One of the first batch of W.A.A.F. flight mechanics doing a job of work on a Hurricane undercarriage.

Sgt. Finn has carried out the duties of section leader for five months, displaying great keenness and devotion to duty.

Sgt. P. G. LOUIS, No. 615 Squadron.—This airman has participated in over 100 operational sorties, including channel sweeps, convoy, and night patrols. Sgt. Louis has taken part in most of his unit's highly successful attacks on enemy shipping, wherein six ships of various types and sizes have been destroyed and others damaged. He has destroyed one Junkers 88 and probably a Messerschmitt 109F. Throughout he has displayed great keenness and devotion to duty.

Act. Flt. Sgt. W. H. ROBINSON, No. 7 Squadron.—In November, 1941, this airman was the flight engineer of an aircraft which participated in a daylight attack on shipping off Borkum. The aircraft was subjected to intense and accurate anti-aircraft fire, and sustained damage to the starboard outer engine oil system.

Owing to the presence of eight enemy fighters, Flt. Sgt. Robinson manned his turret, but, fully realising the danger of the engine seizing, instructed another member of the crew to give him a commentary on the behaviour of the damaged engine. Skilfully dividing his attention between his gunnery and engineering duties, Flt. Sgt. Robinson was able to keep the damaged engine going until the engagement was broken off.

During the battle he shot down one of the enemy aircraft in flames. Afterwards, when the port outboard engine also became unserviceable, Flt. Sgt. Robinson carefully calculated the amount of fuel necessary to reach base, jettisoned as much as possible of the remainder, and so made it possible to return safely on two engines. This airman has participated in many successful operations, on one of which, although wounded, he carried out his duties fully and, until the aircraft was safely landed, he did not indicate that he had been wounded in the groin.

Sgt. F. C. WHITWELL, No. 7 Squadron.—This airman was the rear gunner of an aircraft which carried out a daylight attack on shipping off Borkum. During the operation the aircraft was attacked by a force of eight Messerschmitt 109s. Displaying great coolness and accuracy of fire, Sergeant Whitwell warded off the first four attacks and, in the next one, seriously damaged one of the attackers, which was observed to dive steeply away with the engine emitting black smoke.

Three further attacks were made by the enemy aircraft, and, in the last one, Sgt. Whitwell scored a further success. Following a well-aimed burst by him, one of the enemy aircraft turned over and dived vertically. On another occasion, when his aircraft was attacked by a Messerschmitt 110, Sgt. Whitwell withheld his fire until the attacker had closed to a range of 50 yards, and then shot it down in flames. This airman has displayed great ability, tenacity and courage.

Sgt. H. R. LEVEN, Sgt. M. J. NOLAN, Sgt. C. A. EVANS, all of No. 107 Squadron.—As pilot, air observer and wireless operator-air gunner respectively, Sgts. Leven, Nolan and Evans have participated in numerous sorties in which enemy shipping has been attacked. Undismayed by the heavy defensive fire from armed escort ships, these airmen have shown great courage and determination to complete their allotted task. Sgts. Leven and Nolan have completed 34, and Sgt. Evans 27 operational missions.